Table 4-11 (cont'd)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean Ann. (m3/sec)	Total Ann. (millions m3)
Subbasins Contributing to Samangan, Balk, Jawzjan, Faryab Area														
sb401 avg monthly flow	18.38	25.19	25.82	26.87	37.26	69.19	126.30	100.62	23.51	7.93	7.58	13.19	40.15	1266.3
sb402 avg monthly flow	16.42	22.50	23.06	24.00	33.28	61.80	112.81	89.87	21.00	7.08	6.77	11.78	35.86	1131.0
sb403 avg monthly flow	26.73	36.62	37.54	39.07	54.17	100.58	183.62	146.28	34.17	11.53	11.02	19.18	58.37	1840.9
sb404 avg monthly flow	10.65	14.60	14.96	15.57	21.59	40.09	73.18	58.30	13.62	4.59	4.39	7.64	23.27	733.7
sb405 avg monthly flow	0.00													
total monthly flow (m3/sec)	72.18	98.91	101.39	105.52	146.29	271.65	495.91	395.08	92.29	31.13	29.75	51.80	157.66	4971.9
total monthly flow (millions m3)	193.3	256.4	271.6	282.6	353.9	727.6	1285.4	1058.2	239.2	83.4	79.7	134.3	157.5	4965.5
monthly demand wheat	124.8	58.4	18.1	12.1	28.2	62.4	128.9	161.1	36.2	0.0	0.0	0.0		630.3
monthly demand other	15.5	0.0	0.0	0.0	0.0	0.0	20.2	35.2	93.7	93.2	61.8	21.8		341.3
monthly demand maize	6.6	0.0	0.0	0.0	0.0	0.0	8.6	15.0	39.8	39.6	26.2	9.2		144.9
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	40.2	29.8	29.9	9.5		113.6
total monthly demand (millions m3)	147.0	58.4	18.1	12.1	28.2	62.4	157.7	215.4	210.0	162.6	117.7	40.5		1230.1
total gross demand (n=0.50)	294.0	116.8	36.2	24.2	56.4	124.8	315.3	430.8	420.0	325.3	235.5	81.1		2460.3
Ratio of Supply to Demand	65.8%	219.5%	749.2%	1169.6%	627.7%	582.8%	407.7%	245.6%	57.0%	25.6%	33.8%	165.6%		201.8%
Supply – Demand (millions m3)	–100.6	139.6	235.3	258.5	297.5	602.7	970.1	627.4	–180.7	–241.9	–155.8	53.2		2505.3
Subbasins Contributing to Badakshan, Bamian, Baghlan, Kunduz, Takhar Area														
sb406 avg monthly flow	0.00													
sb407 avg monthly flow	106.43	106.43	100.49	90.04	84.75	91.98	127.07	234.39	502.33	297.35	151.70	83.06	164.67	5193.0
sb408 avg monthly flow	56.25	56.25	53.12	47.59	44.80	48.62	67.16	123.89	265.51	157.16	80.18	43.91	87.04	2744.8
sb409 avg monthly flow	81.31	81.31	76.77	68.79	64.75	70.27	97.07	179.07	383.76	227.16	115.90	63.47	125.80	3967.3
total monthly flow (m3/sec)	243.98	243.98	230.38	206.42	194.30	210.86	291.30	537.35	1151.59	681.67	347.78	190.45	377.51	11905.0
total monthly flow (millions m3)	653.5	632.4	617.0	552.9	470.0	564.8	755.0	1439.2	2984.9	1825.8	931.5	493.7	378.0	11920.8
monthly demand wheat	73.4	34.3	10.7	7.1	16.6	36.7	75.7	94.7	21.3	0.0	0.0	0.0		370.4
monthly demand other	14.8	0.0	0.0	0.0	0.0	0.0	19.2	33.5	89.2	88.7	58.6	20.7		324.7
monthly demand maize	5.1	0.0	0.0	0.0	0.0	0.0	6.6	11.6	30.8	30.7	20.3	7.2		112.3
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	201.9	149.8	150.4	48.0		570.9
total monthly demand (millions m3)	93.3	34.3	10.7	7.1	16.6	36.7	101.6	160.5	343.3	269.2	229.3	75.8		1378.2
total gross demand (n=0.50)	186.5	68.6	21.3	14.2	33.1	73.4	203.2	321.0	686.5	538.3	458.6	151.6		2756.5
Ratio of Supply to Demand	350.3%	921.4%	2896.7%	3893.3%	1418.6%	769.7%	371.6%	448.4%	434.8%	339.1%	203.1%	325.6%		432.5%
Supply – Demand (millions m3)	467.0	563.8	595.7	538.7	436.9	491.4	551.9	1118.3	2298.4	1287.4	472.9	342.0		9164.3
Subbasins Contributing to Kabul, Logar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar Area														
sb501 avg monthly flow	271.55	452.34	462.84	537.11	478.59	537.11	1277.50	798.16	170.28	96.02	79.52	159.78	443.40	13983.1
sb502 avg monthly flow	27.01	44.99	46.03	53.42	47.60	53.42	127.05	79.38	16.94	9.55	7.91	15.89	44.10	1390.7
sb503 avg monthly flow	55.34	92.19	94.33	109.46	97.54	109.46	260.36	162.67	34.70	19.57	16.21	32.56	90.37	2849.8
sb504 avg monthly flow	93.88	156.38	160.01	185.69	165.46	185.69	441.66	275.94	58.87	33.20	27.49	55.24	153.29	4834.2
total monthly flow (m3/sec)	447.79	745.90	763.21	885.68	789.19	885.68	2106.57	1316.14	280.79	158.33	131.12	263.48	731.16	23057.7
total monthly flow (millions m3)	1199.3	1933.4	2044.2	2372.2	1909.2	2372.2	5460.2	3525.2	727.8	424.1	351.2	682.9	729.4	23001.9
monthly demand wheat	77.8	36.4	11.3	7.5	17.6	38.9	80.4	100.4	22.6	0.0	0.0	0.0		393.0
monthly demand other	14.4	0.0	0.0	0.0	0.0	0.0	18.7	32.7	86.9	86.5	57.2	20.2		316.5
monthly demand maize	14.2	0.0	0.0	0.0	0.0	0.0	18.5	32.2	85.7	85.3	56.4	19.9		312.2
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	94.2	69.9	70.2	22.4		266.3
total monthly demand (millions m3)	106.5	36.4	11.3	7.5	17.6	38.9	117.6	175.0	289.5	241.6	183.7	62.4		1288.0
total gross demand (n=0.50)	212.9	72.8	22.6	15.1	35.2	77.8	235.1	350.0	579.0	483.2	367.4	124.9		2576.0
Ratio of Supply to Demand	563.3%	2655.0%	9045.5%	15745.3%	5431.0%	3047.5%	2322.3%	1007.3%	125.7%	87.8%	95.6%	546.8%		892.9%
Supply – Demand (millions m3)	986.4	1860.5	2021.6	2357.1	1874.1	2294.4	5225.1	3175.2	148.8	–59.2	–16.2	558.0		20425.9

TOTAL ANNUAL SUPPLY	58522.3
TOTAL ANNUAL DEMAND	11973.6
DIFFERENCE	46548.7

Source: Analysis of Current Regional Supply/Demand by Nathan–Berger team.

Only one other region, the northeastern (Badakshan, Bamian, Baghlan, Konduz, Takhar), currently experiences water surpluses every month. Although the limited information available suggests that much of the prewar irrigated area of the region is presently being used to produce crops, approximately 67,600 ha. of prewar irrigated land is estimated to be available.

In spite of the fact that irrigated area has decreased in the remaining regions as a result of the war, none appears to offer short-term opportunities for expanding irrigated agriculture. Water shortages are still experienced in each of these regions at some point during the year (see Table 4-11). Shortages occur in the summer and fall in the southwestern (Nimroz), central (Ghazni), northwestern (Badghis, Herat, Ghor), and northern (Samangan, Balkh, Jowzjan, Faryab) regions. Shortages are experienced in the summer in the western (Farah), and eastern (Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar) regions. The regions experiencing the most severe shortages include the western (Nimroz) and central regions (Ghazni) where the ratio of supply to demand dips as low as 10 percent. The eastern region has the smallest shortages with a supply-to-demand ratio of 90 percent during the lowest month. Shortages occur primarily as a result of the high water demand from major crops like maize and rice. The impact of these shortages in each region is a function of the degree of the shortage and the types of crops grown with lower yields expected in the affected crops.

Because more area was irrigated before the war in these regions, rehabilitation of agricultural lands to prewar levels will add further demands to the already overloaded water supply. In order to obtain optimum levels of production and expansion of crop areas, significant planning and investment will be necessary in order to construct new water storage and distribution facilities.

Chapter 5

PROJECT PRIORITIES AND STUDY RECOMMENDATIONS

This chapter presents recommendations about priority water development projects and other activities that A.I.D. and other donors should consider financing. Project regional resettlement priorities are discussed in the light of the constraint analysis presented in Chapter 4. Recommendations for additional studies are then presented.

Project and Regional Priorities

Afghanistan's climate and topography force primary reliance on irrigation. As a result of the years of drought, most Afghan farmers adopt a defensive attitude when making decisions concerning areas to be planted and investment in agricultural inputs. Well-established farmers require 2 or 3 years to recover from a single crop failure caused by drought. For others in less fortunate circumstances, crop failure can mean loss of land and starvation for their families. Under such circumstances, uncertainty about future water availability leads to conservative planting decisions.

Rain-fed agriculture is particularly vulnerable in drought years. A prudent family-farming strategy relies on the most productive irrigated land to provide food and basic family necessities, expands the irrigated area to be planted in years when plentiful surface flows are anticipated, and treats rain-fed dry land areas as a high risk source of supplemental income during years when the weather is expected to be favorable. The more prosperous the farmer and the more reliable the predictions of surface water flows and local rainfall, the more rational it becomes to plant marginal land.

A prudent farming strategy relates information on water availability to the various categories of land within a single economic unit. The strategy necessitates a degree of prosperity sufficient to permit some risk-taking and available marginal land that can be put into production or allowed to lie fallow according to conditions. However, the strategy becomes life-threatening if farmers lack good irrigated land and farming skills. Most refugees are rural

have-nots. To expect large numbers of these refugees to support themselves primarily on marginal land and on dryland agriculture would court rural catastrophe.

The key to successful refugee return to rural Afghanistan is the availability of sufficient irrigated land to support the resettled population. The land that they settle must be arable and water must be reliably available at the time of their return. Projects to increase the amount of irrigated agriculture in particular regions are divided into four priorities.

- **First Priority** projects can be undertaken now with a minimum amount of planning and a low level of investment. They offer the quickest means of bringing additional irrigated lands into production.

- **Second Priority** water resources development projects are those that were in progress and partially completed when hostilities broke. These projects will require more investigation and preparation than First Priority projects, but will benefit from past experience.

- **Third Priority** water resources projects were still in the planning stages when hostilities began.

- **Fourth Priority** water resource projects are entirely new.

These priorities and their implications are discussed below.

First Priority Projects

In the near term, opportunities for expanding agriculture, and therefore the numbers of additional people that can be supported, appear to be limited primarily to previously irrigated lands within regions having adequate year-round water supplies (the southern and northeastern regions). Significant expansion of irrigated agriculture beyond the 175,000 ha. of readily available land estimated for these regions will require significant additional planning and consequently, greater lead times and investment.

Southern Region

Because of its adequate water supply and the relatively superficial damage to Helmand-Arghandab irrigation networks, the southern region presents one of the few opportunities where a relatively low level of inputs would be required to expand the amount of irrigated land.

Several steps were followed to estimate the additional population that could be supported through rehabilitation of the irrigation infrastructure in this region. First, the irrigated area not presently farmed was calculated on the basis of the difference between prewar and current irrigated crop areas (see Tables 4-7 and 4-10). This value was used as an upper limit for estimating the amount of potentially irrigable land. Next, the current conditions water-supply model was used to calculate the amount of additional crop area that could be irrigated given the available water supply. A straight percentage increase was applied to each crop area (automatically increasing demand in the spread sheet) until crop demands exceeded water supply. The lesser of this value or the limiting value from above was used as the estimate for potentially irrigable land.[34]

An average grain yield was developed for the region on the basis of SCA data on grain crop yields. The product of this average yield and the potential additional irrigated area provides an estimate of the potential additional production. Net additional production was then computed using a loss factor of 20 percent, the same loss factor applied in the AFGRAIN model. Lastly, additional population that could be supported was calculated using an annual cereal requirement of 180 kg for each person. The 180-kg figure is used by the FAO and others as the minimum cereal equivalent consumption required per person to maintain good health. Net production divided by 180 yields an estimate of the number of additional people that could be supported by the additional grain production.

If the Helmand-Arghandab system is rehabilitated to prewar levels of production, it could potentially support approximately 700,000 people. The computation is summarized in Table 5-1.

Table 5-1. Potential Additional Production and Number of People Supported

Region	Estimated Prewar Irrigated Area Not Currently Farmed (ha.)	Average Grain Yield (kg/ha.)	Potential Additional Production (kt)	Net Production (kt)	Additional Population Supported (millions)
Southern	107,000	1,480	158	127	0.70
Northeastern	67,600	1,920	130	104	0.58
Total	-	-	-	-	1.28

Note: kt indicates kilotons.

[34]This computation was carried out for both the southern and northeastern regions. In both cases, the amount of additional area that could be irrigated exceeded the upper limit imposed by the difference in prewar and current conditions in irrigated areas.

O/AID/Rep reports that both DAI and MCI have studies in various stages of completion that examine the potential of the Helmand-Arghandab water distribution network as a candidate for a project that would have significant impact.

Northeastern Region

Data available describing the present conditions in the agricultural areas of the northeast are very limited. However, discussions with personnel from the Refugee Policy Group, who have visited the area, indicate that much of the region is being actively farmed.[35] It is therefore assumed that, like the southern region, only a low level of input would be required to bring the remaining unused irrigated lands back into production. The estimate of additional population that could be supported by rehabilitating these lands is calculated as previously described. Available irrigable land of 67,600 ha. was multiplied by an average grain yield of 1920 kg per ha. for the region to yield potential increased production of 130 kt and net production of 104 kt. Additional population that could be supported by this additional production is approximately 580,000 people (see Table 5-1).

Total estimated production from rehabilitated irrigable land in the two First Priority areas suggests that these two areas together might support an additional 1.28 million people. The total refugee population for the country was estimated to be approximately 4.55 million people in 1990. Of this amount, 698,400 and 550,600 refugees were estimated for the southern and northeastern regions, respectively.[36] If all previously irrigated land was brought into production in the southern region, production from this land would be exactly enough to feed the number of refugees estimated to have come from the region. In the northeastern region, the additional production would also be exactly sufficient to support the estimated number of refugees for that region. It should be noted that both of these regions were estimated to have had surplus grain production in 1990.[37] Because of this cushion of surplus and the apparent availability of additional irrigable land, these areas are the most attractive for initial rehabilitation efforts. With inputs at the level described by Assifi,[38] it is likely that refugees returning to these regions could be absorbed with relatively few problems.

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[35]Interview with Michael Knowles of the Refugee Policy Group, September, 1991.

[36]Eighmy, T. *Afghanistan's Population Inside and Out: Demographic Data for Reconstruction and Planning.* Office of the A.I.D. Representative for Afghanistan Affairs, 1990.

[37]*AFGRAIN*, Nathan-Berger, 1991.

[38]Assifi, *An Assessment of Helmand Valley*, 1991.

Second and Third Priority Projects

The Soviet invasion halted construction and planning activities on many irrigation projects that were in progress in the late 1970s. In the northeastern region, the Khanabad I project, designed to improve irrigation on approximately 30,000 ha. of land, was about 80 percent complete in 1978. In the northwestern region, the Hari Rud project, designed to improve irrigation on about 40,000 ha., was about 10 percent complete when construction was halted. Other development projects had been started and were in various stages of completion when government attention and resources were shifted to issues related to the war. Table 5-2 summarizes these projects and provides information on project status, proposed improvements, estimated time to complete, and other relevant factors. Rough estimates are provided for the additional production and numbers of people that could be supported by completion of these projects.

Assuming only grain were to be grown in these project areas, the estimated production would support approximately 1.03 million additional people. Added to the estimate for First Priority projects, the total additional population that could be supported by First, Second, and Third Priority short- to medium-term projects is about 2.31 million, about half of the 4.55 million refugees estimated countrywide.

However, these projects will reduce the strain imposed by repatriation and could be assigned a priority on the basis of regional need, length of time to complete, and estimated production potentials. Table 5-3 presents information on regional population, refugee status, and estimates of food grain status, which are combined to represent reasonably strong indicators of need.

As an example, for the eastern region, composed of the provinces of Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar and Nangarhar, the ratio of projected 1990 population (including refugees) to prewar population is 1.43. This region currently experiences large grain deficits and that substantial quantities of imported grain have been required. An additional 1.46 million refugees will exacerbate these problems and will not be easily absorbed into the region.

Based on the water supply model for the region, water shortages, although minor, are currently experienced during the summer months and will limit the amount of additional land that can be brought under cultivation in the short term. Expansion of agricultural lands will require bringing additional water supply projects on-line. From Table 5-2, the Kama project, the largest proposed project with an estimated 5-year completion time, will add only 5,900 ha. No projects planned or under development will add enough hectares to even approach the productive capacity necessary to satisfy the total food requirements for the eastern region. Continued importation of grain will probably be required during at least the short to

Table 5-2. Summary of Potential Projects

Region	Project	Planned Amount of New or Improved Land (ha.)	Project Status	Years to Complete	Average Grain Yield (kg/ha.)	Estimated Additional Grain Production (kt)	Net Production (kt)	Estimated Additional Population Supported (thousands)
Western	Farah Rud	61,000 improved	Feasibility study	7.0	1,000.0	61.0	48.8	271.1
Southwestern	none	NA	NA	NA	NA	NA	NA	NA
Southern	Kajakai Gates	26,000 new	50% complete	3 to 5	1,800.0	46.8	37.4	208.0
Southeastern	Sardeh	12,000 new	50% complete (1980)	2.0	1,800.0	21.6	17.3	96.0
		1,100 improved	0% complete	< 1	1,000.0	1.1	0.9	5.0
Central	none	NA	NA	NA	NA	NA	NA	NA
Eastern	Nangarhar	18,000 new	100% complete (1980)	NA	NA	NA	NA	NA
		6,500 new	not feasible	NA	NA	NA	NA	NA
	Parwan	no additional	NA	NA	NA	NA	NA	NA
		600 new	60% complete	< 1	1,800.0	1.1	0.9	4.8
	Nahr-e-Karim	140 improved	0% complete	< 1	1,000.0	0.1	0.1	0.6
		3,320 new	Feasibility study	5.0	1,800.0	6.0	4.8	26.6
		5,880 improved	Feasibility study	5.0	1,000.0	5.9	4.7	26.1
Northeastern	Khanabad I	26,600 improved	80% complete	2.0	1,000.0	26.6	21.3	118.2
	Khanabad II	13,660 improved	0% complete	5.0	1,000.0	13.7	10.9	60.6
		1,200 new	0% complete	2.0	1,800.0	2.2	1.8	10.0
	Gawargan and	3,400 new	50% complete	3.0	1,800.0	6.1	4.9	27.2
	Chardarah	24,000 improved	50% complete	3.0	1,000.0	24.9	19.9	110.7
	Sang-e-Mehr	1,270 new	60% complete	2.0	1,800.0	2.3	1.8	10.2
Northern	none	NA	NA	NA	NA	NA	NA	NA
Northwestern	Hari Rud	40,000 improved	10% complete	3-5	1,000.0	40.0	32.0	177.8
Total	-	-	-	-	-	-	-	1152.9

[a]For improved irrigation, yield is additional gained from improved irrigation conditions.

Note: NA indicates information not applicable. Detailed descriptions of projects are presented on pages 45 to 60 of this report.

Table 5-3. Refugee Summary by Region

Region and Province	1978–79(a)	Pop. 1990 Adj.(b)	Pop. 1990 Proj. (b)	Pak. Refugees	Iran Refugees	Nomads/ Allocated(c)	Ratio of '90 Proj. Pop. to '78 Pop.	1990 Adj. Foodgrain Surplus/ (Deficit) (d) (kt)	1990 Proj. Foodgrain Surplus/ (Deficit) (d) (kt)
Western:									
Farah	308,907	130,608	379,274	11,566	237,100	0	122.8%	45	1
Southwestern:									
Nimroz	122,036	50,928	139,972	4,044	85,000	0	114.7%	10	(6)
Southern:									
Helmand	517,645	337,001	546,546	212,941	50,400	53,796	105.6%	26	(11)
Kandahar	574,954	474,051	737,762	292,434	37,200	65,923	128.3%	(3)	(51)
Zabul	179,362	127,134	186,114	60,457	4,100	5,577	103.8%	(13)	(24)
Oruzgan	436,418	460,932	501,795	9,863	31,000	0	115.0%	76	69
total	1,708,379	1,399,118	1,972,217	575,695	122,700	125,296	115.4%	86	(17)
Southeastern:									
Paktya	484,023	221,890	524,396	529,807	0	227,301	108.3%	(26)	(80)
Paktyka	245,229	187,679	250,854	94,295	0	31,120	102.3%	(14)	(25)
total	729,252	409,569	775,250	624,102	0	258,421	106.3%	(40)	(105)
Central:									
Ghazni	646,623	700,794	770,684	52,090	17,800	0	119.2%	106	93
Eastern:									
Kabul	1,373,572	2,052,781	2,280,417	250,082	100,000	122,446	166.0%	(308)	(348)
Logar	216,303	101,661	264,974	215,737	0	52,424	122.5%	(1)	(31)
Wardak	287,605	372,202	398,910	17,708	9,000	0	138.7%	(46)	(51)
Parwan	409,510	488,748	530,678	38,330	3,600	0	129.6%	(52)	(60)
Kapisa	345,775	423,160	433,163	10,003	0	0	125.3%	(31)	(33)
Laghman	310,745	297,509	379,064	81,555	0	0	122.0%	8	(6)
Kunar	250,132	146,799	308,607	210,996	0	49,188	123.4%	2	(28)
Nangarhar	745,986	533,912	1,032,046	519,957	0	21,823	138.3%	(60)	(150)
total	3,939,628	4,416,772	5,627,859	1,344,368	112,600	245,881	142.9%	(488)	(707)
Northeastern:									
Badakshan	497,758	554,059	554,375	316	0	0	111.4%	211	211
Bamyan	268,517	301,530	317,143	213	15,400	0	118.1%	(3)	(6)
Baghlan	493,882	275,614	484,776	221,263	1,500	13,601	98.2%	172	135
Kunduz	555,437	367,891	576,574	293,623	0	84,940	103.8%	103	65
Takhar	519,752	539,295	557,532	18,237	0	0	107.3%	352	349
total	2,335,346	2,038,389	2,490,400	533,652	16,900	98,541	106.6%	835	754

Table 5-3 (cont'd)

Region and Province	1978–79(a)	Pop. 1990 Adj.(b)	Pop. 1990 Proj. (b)	Pak. Refugees	Iran Refugees	Nomads/ Allocated(c)	Ratio of '90 Proj. Pop. to '78 Pop.	1990 Adj. Foodgrain Surplus/ (Deficit) (d) (kt)	1990 Proj. Foodgrain Surplus/ (Deficit) (d) (kt)
Northern:									
Samangan	272,584	292,968	312,524	18,156	1,400	0	114.7%	22	19
Balkh	569,255	585,665	629,122	40,857	2,600	0	110.5%	135	127
Jawzjan	588,609	608,062	677,883	59,121	10,700	0	115.2%	139	126
Faryab	582,705	665,971	674,001	6,730	1,300	0	115.7%	(14)	(15)
total	2,013,153	2,152,666	2,293,530	124,864	16,000	0	113.9%	282	257
Northwestern:									
Badghis	233,613	150,427	317,527	0	167,100	0	135.9%	30	0
Herat	676,422	382,685	870,404	719	487,000	0	128.7%	97	9
Ghor	337,992	302,497	318,379	382	15,500	0	94.2%	(17)	(19)
total	1,248,027	835,609	1,506,310	1,101	669,600	0 258,317 (unallocated)	120.7%	110	(10)
TOTAL	13,051,351	12,134,453	15,955,496 16,941,952 (includes nomads)	3,271,482	1,277,700	986,456	122.3% 129.8%	946	260

Sources: (a) GOA Census
(b) Adjusted population equals 1990 projected population minus refugee population in both Iran and Pakistan plus nomadic population allocated to each province based on algorithm developed by AID Rep.
(c) Includes nomads and internally displaced who enter Pakistan border areas. The unallocated (includes the unassigned from the original AID Rep. analysis) move between Afghanistan and Pakistan.
(d) Adopted from Nathan–Berger AFGRAIN model.

medium term. Allocation of resources to water supply projects in the eastern region should be given a relatively low priority.

The northeastern region, designated as a First Priority area because of its excess of water supply, is also attractive because of its numerous partly completed agricultural projects. Addition of these projects, of which many are close to completion, would add significant productive capacity to the area in a relatively short time (an estimated 2 to 3 years for each project). This area is made even more attractive by its proximity to the eastern region, particularly Kabul. On the basis of these factors, a high priority should be given to water development in this region.

The same is true of the southern region, where the addition of an already procured set of gates to the Kajakai Dam would allow irrigation of an additional 26,000 ha., which would allow additional production that could potentially feed about 200,000 more people. Proximity of this area to the eastern, southeastern, and southwestern regions, which all experienced foodgrain deficits in 1990, make it an attractive area in which to focus water development efforts.

As demonstrated by the water supply model, the northwestern region will require water storage projects in order to increase its irrigated agriculture. This region has one of the highest refugee populations; an estimated 670,000 people were forced out and currently live in Iran. The Hari Rud Project, which includes a dam and reservoir, would improve irrigation on 40,000 ha. of land, potentially feeding an additional 178,000 people. Although it is generally believed that refugees who settle in Iran are less likely to return to Afghanistan than those who fled to Pakistan[39], the Hari Rud Project would satisfy the demand of at least a portion of this number. Thus, a relatively high priority should be allocated to completion of this project.

Fourth Priority Projects

Afghanistan's annual water supply greatly exceeds the demands that are currently placed on it. Table 5-4 provides a gross estimate of the additional production that would be possible if *all* surplus water could be stored and used to irrigate grain crops. For this computation, it was assumed that short- to medium-term agricultural developments would increase water demand to at least the level experienced before the war. The calculation of additional crop area is therefore based on prewar annual surpluses because these reflect the long-term available water supply more effectively than current annual surpluses.

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[39] *Operator Salam Third Consolidated Report*, Office of the U.N. Coordinator for Humanitarian and Economic Assistance Programmes Relating to Afghanistan, 1990.

Table 5-4. Annual Water Supply Surplus and Deficit and Estimate of Additional Hectarage that Could be Irrigated

Region and Province	Prewar Surplus/ (Deficit) (m^3)	Current Surplus/ (Deficit) (m^3)	Potential Additional Crop Area (ha.)	Potential Grain Production (kt)	Net Production (kt)	Estimated Additional Population Supported (millions)
West						
Farah	3040	3270	0.236	4234	339	1.88
Southwest						
Nimroz	1840	2050	0.143	257	205	1.14
Southern						
Helmand	-	-	-	-	-	-
Qandahar	-	-	-	-	-	-
Oruzgan	-	-	-	-	-	-
Zabul	-	-	-	-	-	-
Total	5490	6400	0.426	766	613	3.40
Southeastern						
Paktya	-	-	-	-	-	-
Paktika	-	-	-	-	-	-
Total	603	884	0.047	84	67	0.37
Central						
Ghazni	-210	-110	-	-	-	-
Eastern						
Kabul	-	-	-	-	-	-
Logar	-	-	-	-	-	-
Wardak	-	-	-	-	-	-
Parwan	-	-	-	-	-	-
Kapisa	-	-	-	-	-	-
Laghman	-	-	-	-	-	-
Konar	-	-	-	-	-	-
Nangarhar	-	-	-	-	-	-
Total	2020	20400	1.57	2817	2254	12.52

Table 5-4 (continued)

Region and Province	Prewar Surplus/ (Deficit) (m^3)	Current Surplus/ (Deficit) (m^3)	Potential Additional Crop Area (ha.)	Potential Grain Production (kt)	Net Production (kt)	Estimated Additional Population Supported (millions)
Northeastern	-	-	-	-	-	-
Badakshan	-	-	-	-	-	-
Bamian	-	-	-	-	-	-
Baghlan	-	-	-	-	-	-
Kunduz	-	-	-	-	-	-
Takhar	-	-	-	-	-	-
Total	8090	9160	0.627	1128	903	5.01
Northern						
Samangan	-	-	-	-	-	-
Balkh	-	-	-	-	-	-
Jawzjan	-	-	-	-	-	-
Faryab	-	-	-	-	-	-
Total	1100	2500	0.085	153	123	0.68
Northwestern						
Badghis	-	-	-	-	-	-
Herat	-	-	-	-	-	-
Ghor	-	-	-	-	-	-
Total	1450	1950	0.113	202	162	0.90
Total	41600	46500	3.25	5,831	4,665	25.92

Note: These calculations are based on prewar water supply surpluses, average grain crop demands, and 50 percent losses.

If all unused, extra water that flows down rivers in Afghanistan in an average year could be put to use, it would irrigate approximately 3.24 million additional ha. With average grain yields, this land could support an estimated 25.9 million additional people.

The major limitation to developing this water supply is the availability of arable land. Although uncultivated arable land is estimated at 4.85 million ha. (4.04 million ha. in 1978-1979),[40] much of the remaining arable land is outside the reach of the traditional and modern canal irrigation systems. As stated previously, the vast majority of readily irrigable land is in the valley bottoms and has long since been brought under production. New agricultural projects will have to incorporate not only water storage and distribution components to conserve and deliver water, but are also likely to include pumping plants to lift water to the higher-elevation agricultural areas that are presently only dry-farmed or not farmed at all. Several of the projects listed in the previous section incorporated pumping plants in the later phases of the proposed developments.

These will be complex and expensive projects that will require extensive planning, analysis, and time to implement. Thus, although the potential appears to be great at the outset (illustrated by the gross estimate of surplus water supply and agricultural production), the trade-off is the high cost in time and resources. For this reason, these types of projects are given the lowest priority.

Principal Implications of the Analysis

The water supply constraints analysis in this report seeks to quantify the constraints on agriculture imposed by limitations on the availability of water. Both prewar and current conditions have been examined. Principal implications may be summarized as follows:

- For both prewar and current conditions, the constraint analysis showed all but two of the regional drainage areas to be constrained by monthly shortages of water supply during the low flow season (approximately June to October). The primary reason for these shortages is that crop demands for water are still relatively high during this period, while river flow levels are approaching their lowest. Policy makers should be cautious about encouraging refugees to return to these areas, particularly if there is little assurance that support systems will be in place.

- Seasonal shortages imply that, except for improvements in system efficiency, short-term attempts to expand irrigated agriculture for returning refugees will probably increase the demand for systems

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[40]Nathan-Berger, *Land Ownership*, 1991.

that are already overloaded. The impact of adding crop-water demand without also adding water supply would be lowered productivity for the existing, as well as rehabilitated, crop areas. Thus, in the short-term, only regional drainage areas that experience no monthly water shortages have significant potential for supporting additional irrigated agriculture.

- Increased production can be achieved by decreasing the amount of water that is lost through inefficient water distribution systems and farm use. In areas that experience water shortages, improvements in efficiency would almost certainly increase crop yields because more water would be available to existing crops. In areas with no water shortages, these improvements would allow additional lands to be brought into production. To the extent that refugees can be trained in water control technologies before their return, their prospects for survival in the countryside will be enhanced.

The Limits of Sectoral and Regional Prioritization

Sociopolitical considerations will clearly be important as Afghanistan's leadership seeks to counter the centripetal forces unleashed by more than a decade of warfare and to reintegrate the country as a national entity. Conceivably policies of "uniformity" in handling refugee return could contribute to the re-establishment of a social and political consensus, as could the traditional process of taking regional, ethnic, and political considerations into account in allocating infrastructure projects.

Two points should be borne in mind as sociopolitical imperatives are integrated with economic and technical objectives and assessments of human needs. First, most needs for water arise at the farm, household, and community levels. Making allocation decisions on the basis of need averaged across large areas can do an injustice to have-not communities within regions that appear to have a surplus or approximate balance. Second, a multisectoral perspective is often best suited to circumstances in which sociopolitical considerations strongly affect resource allocation decisions. One area may be best served by upgraded water infrastructure, another by improved roads, a third by better health facilities. The wider and more flexible the menu of projects that can be practically offered and delivered, the more likely it is that multiple objectives can be achieved at a reasonable cost.

Recommendations for Further Study

Conducting the water constraints analysis revealed the dearth of information on water resources for Afghanistan. Although many of the reports reviewed offered generalized descriptions of regional water conditions, few

contained data at the level of detail necessary to make informed decisions about specific projects and investments. Of particular concern were project feasibility studies, conducted in the past, that attempted to base technical recommendations concerning project feasibility on water data collected over only 2 to 3 years.

Unfortunately, no centralized, country-wide system for collecting water data (streamflow, groundwater) has ever been developed in Afghanistan. The minimal amount of historic water data available has been collected for specific projects. The most extensive data collection network was the one set up for the Helmand Valley project. This regional system collected data throughout the Helmand-Arghandab and Hari Rud drainages. Data were collected from the late 1940s to the mid 1970s, primarily by Afghans who underwent extensive training in stream gauging and data reduction techniques and equipment repair and maintenance procedures.

Because basic data are so important to decision making concerning water resources projects, an effort should be made as early as is practical, following the establishment of an acceptable government, to put in place a basic gage network on important streams and in important headwater areas. Although this type of activity may seem less urgent than a number of other repatriation problems, the information collected will be invaluable when the country faces, as it will, decisions concerning large-scale water projects. Data on snow pack and snow melt are particularly important and deserves high-priority attention.

The principal recommendations of the Nathan-Berger team for further study, research, and training activities in the near term follow.

Studies of Local Irrigation System Conditions and Potentials

The project and regional priorities identified in this report were derived on the basis of a desk-top study, using information of distinctly limited currency, detail, and comprehensiveness. It is quite conceivable that assessments for particular regions—and for particular areas within those regions—will change as better, more complete, and more specific information becomes available. What is not likely to change, however, are the conclusions that water availability represents a serious constraint on resettlement in most of Afghanistan. It is important for political leaders and donors to have the best available knowledge of these constraints as they formulate policies, allocate funding, and make other decisions affecting the survival of returning refugees. Cross-border studies of the condition of local irrigation systems and of the potentials of specific areas to support returning refugees should be undertaken. Such studies can be initiated on a pilot basis.

High-priority attention should be given to the southern and northeastern and northeastern drainage regions where short-term rehabilitation efforts are expected to provide additional productive farming areas for repatriated refugees. Much more specific data on the condition of farms and water systems in these areas are required before detailed plans and recommendations concerning rehabilitation efforts can be developed.

Initial reconnaissance efforts should focus on agricultural areas in these two regions. Detailed information to be gathered should include the following:

- Locations and areas of crops and fallowed lands, types of soils and general condition of farms in each agricultural area;
- Locations, dimensions, numbers, types and condition of canals, turnouts, siphons, crossings, diversion structures, and other irrigation system infrastructure;
- Types, numbers and condition of farm equipment being used;
- Condition of maintenance facilities and availability of parts;
- Size and condition of storage and processing facilities;
- Disposition of crops (any processing, locally consumed, exported);
- Information concerning irrigation system management and efficiency;
- Information concerning the economic status of farmers and their attitudes toward water distribution issues presented by resettlement.

Framework for National Water Resource Development

Uncertainties concerning the magnitude, motivation, and pace of refugee return may tempt decision makers to defer until later consideration of a basic plan for water resource development. However, there is danger that ad hoc donor and government decisions made under the pressure of day-to-day developments could preempt rational long term allocation of scarce resources—among watersheds and among such potentially competing requirements as irrigation and energy production. Enough information is currently available to permit the development of a framework that would help decision makers to orient measures taken in immediate support of resettlement toward the achievement of longer-term water development objectives, as well.

Urban Water and Sanitation Systems Studies: Approach Formulation

Afghanistan's cities are presently overcrowded. Natural disasters and problems in the implementation of programs designed to return refugees to the countryside could cause further in-migration. With O/AID/Rep relocation in Kabul, the Mission will probably recognize a need to add a variety of urban projects to its program. Approaches to improving urban water supply and sanitation systems can be developed before refugees return and would represent a prudent investment in the future diversification of the Mission's portfolio.

Improving Capabilities in Irrigation System Planning, Management, and Operation

Serious deficiencies in design, planning, management, and operations have plagued Afghanistan's water resources development projects in the past. The implementability of second, third, and fourth priority projects may well depend on human and organizational capabilities in these areas. Short- and long-term approaches for providing such capabilities should be formulated.

For the short-term, particular attention should be given to (a) identifying and recruiting Afghans with prior water systems experience; (b) upgrading the skills of mirabs and lead farmers; and (c) filling gaps in capability through temporary assignments of foreign technical personnel where there is no other satisfactory alternative. A long-term training program should be designed to create the indigenous technical and managerial capabilities needed to plan and operate Afghanistan's water systems effectively. Such a program should include training of water users, mirabs and (where appropriate) water-user association staff, project operation and management staff, and senior project management staff. It also should include academic programs designed to produce graduates with appropriate technical and managerial skills. A proper balance should be maintained between training and technical rehabilitation and upgrading of irrigation systems.[41]

The Helmand Arghandab Valley Authority successfully provided technical training to qualified young men to act as *mirabs* (water masters) in

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[41]A review of the state-of-the-art carried out for the Thirteenth International Congress on Irrigation and Drainage suggested that technical ratios could be used to assist policy-makers in determining whether a given irrigation system has reached a technical threshold at which investments in training are likely to pay off. H. Boumendil, "On Improving Water Management Through Training," *General Report (E) of the Thirteenth Congress at Casablanca* (New Delhi: International Commission on Irrigation and Drainage), p. 10.

their local areas. Many of these men continue in this function today with the full support of their local communities. Providing training in technical, administrative, and adjudicatory skills could significantly improve the management of irrigation systems and would help to modify traditional attitudes that have reduced irrigation efficiency in the past. Training programs, aimed at influential farmers and future managers of irrigation systems, should be designed to be introduced early on a cross-border basis.

springtime. Traditional and occasionally modern water control structures are often destroyed or rendered inoperable during the high spring flows.

Most water carried by the country's four principal river systems originates in Afghanistan's central mountains.[1] Principal river drainage systems are presented in Figure 2-2. Because the river systems obtain their water from essentially the same annual sources (precipitation in the form of snow and rain), their seasonal fluctuations are similar. The heaviest flows occur in the spring and early summer. Flash floods are common in the spring, particularly in years of relatively heavy snowfall and rainfall. In the late summer and early winter, river flows are sharply reduced, and some cease altogether. Badakshan, Kunar, and Takhar provinces in northeast Afghanistan contain regions of glaciation. The glaciers represent a long-term ecological asset that can exert a stabilizing effect on water supply during the year and can carry over from year to year. The glaciers lend a steadiness to streamflows in the northeastern region of the country that does not exist elsewhere in Afghanistan.

Almost all agricultural land is in the country's river valleys, near flowing water. River-valley water-table levels are, in general, closely related to streamflows. Streamflow data provide a reasonably good picture of the water supply affecting river valley crop agriculture even where irrigation water is drawn from wells and *karezes* rather than directly from the rivers themselves. In any given year, the amount of irrigated land is almost twice that of rainfed land. Irrigated land is far more productive than rainfed land. In the case of wheat, the irrigated crop accounts for between four and five times the production of rainfed land.

While river systems represent critically important systemic components, they certainly do not fully encompass Afghanistan's water resources. Rivers and streams carry only about 28 percent of the precipitation in Afghanistan in any given year. Lands watered by only rainfall bear rainfed crops, forests, and livestock herds. Although they are generally less productive and less influenced by technological improvement, these rainfed lands also represent vital ingredients of the country's economic, ecological, and sociocultural systems.

Irrigated food and fiber crops dominate Afghanistan's economy, but less than one-eighth of the country's surface area is arable. Only 3 to 4 percent of the surface area is used for irrigated crops in any given year. Approximately 60 percent of the total land area has been classified as pasture, five times the area of all arable land combined. In fact, in Afghanistan's treeless

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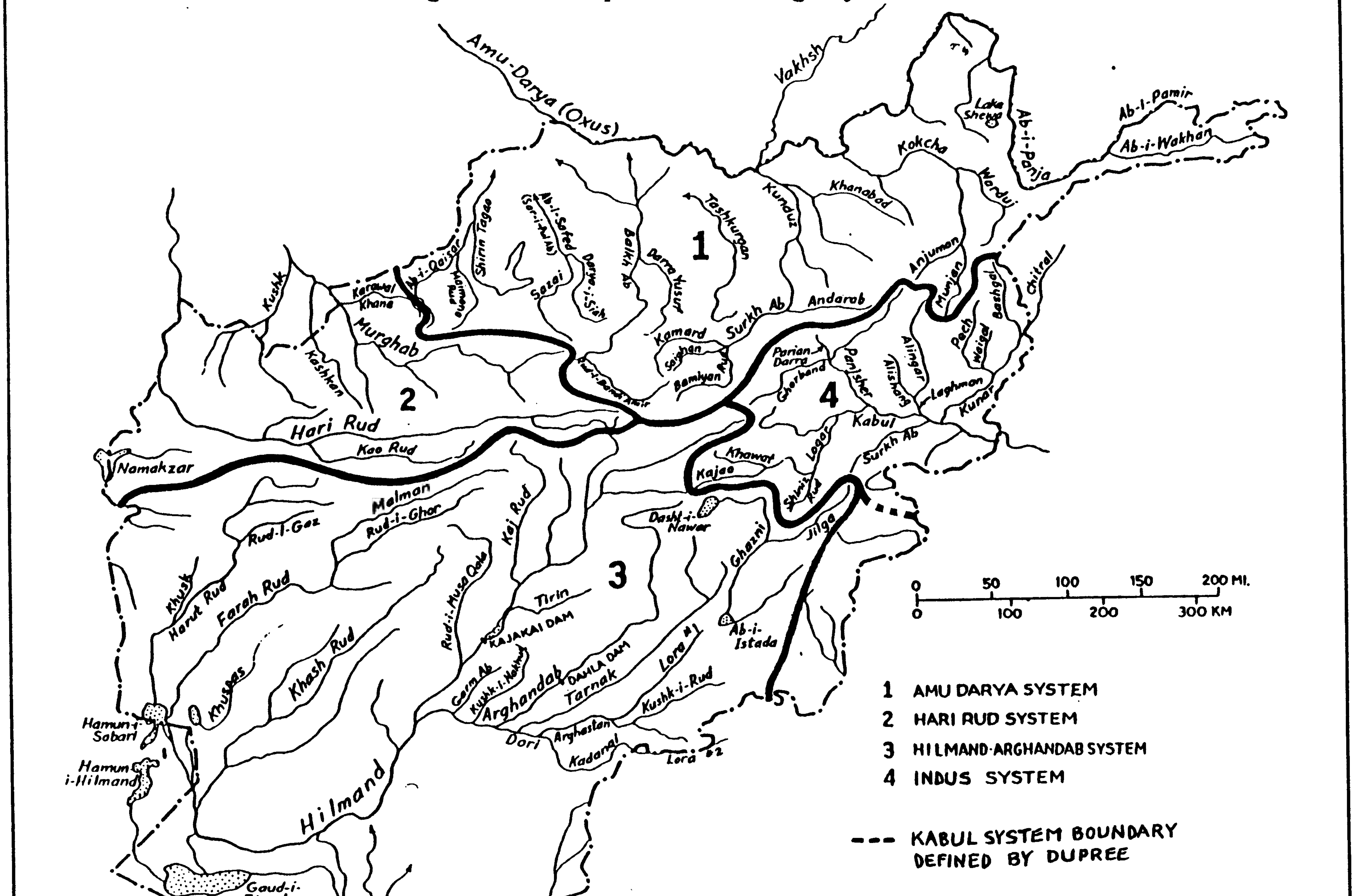
[1]Drainage basin boundaries and the alteration of the southern boundary of the Kabul system on Dupree's map to conform with other descriptions in this report are discussed in detail later in the section on Drainage Basin Definitions in Chapter 2.

Figure 2-2. Principal River Drainage Systems



Source: Adapted from Louis Dupree, Afghanistan, Princeton University Press, 1980.

landscape, more surface area is covered in forests (roughly 2.7 percent in 1989-1990) than rainfed crops in a given year (about 2.4 percent in 1989-1990). In good times, the country's pastures, by supporting livestock, contribute to about one-third of the gross domestic product (GDP) derived from agriculture.

The direct and indirect effects of precipitation on rainfed crop lands, pastures, and forests are highly significant. The behavior of Afghanistan's rainfed "secondary" production systems is particularly noteworthy in hard times and is important to successful refugee return. Before the war Afghanistan's animal herds served as a store of value as well as a source of milk, meat, hides, skins, and wool. These herds grew and diminished in size (with time-lags) as fluctuations in crop-water availabilities affected family income from irrigated agriculture and as precipitation levels changed the carrying capacity of the range from year to year. Irrigated and rainfed agriculture are often united with pastoralism in extended family units. Uncertainties about the prospective magnitude of annual precipitation and cyclical and sectoral trends in snowfall and rainfall significantly affect family strategies for survival, as well as the performance of the national economy.

Climate

Afghanistan's climate is primarily continental, characterized by wide day-night and seasonal temperature changes. Only a small region in the east near Jalalabad is affected by the monsoons of southern Asia, and is sometimes described as subtropical.[2] In most of the country, summers are dry and hot, winters cold and wet with heavy snowfall accumulations in the mountains. In the southern desert regions, temperatures sometimes reach 120°F during the day but may cool to 60°F at night. Winter temperatures in the northern deserts occasionally drop to -10°F at night but can rise to 50°F during the day. Table 2-1 tabulates mean monthly and annual temperatures for selected stations. Station locations and altitudes are shown in Figure 2-3.

Because of its dry climate and seasonally clear skies, Afghanistan receives a larger share of solar radiation than its neighbors to the east.[3] The high rate of solar radiation, the low prevailing humidity, and the strong, steady winds that blow across large sections of the country during the summer result in very high evaporation and transpiration rates. Both of these factors decrease the amount of water available for agricultural, animal, and human use.

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[2]Svendsen, S. *Some Aspects of Irrigation Technology in Afghanistan*. Paper Developed under USAID Contract, No. CSD-2460-211, January 1977, p. 6.

[3]Svendsen, S. *Some Aspects of Irrigation*, p. 8.

Table 2-1. Mean Monthly Temperatures for Selected Meteorological Stations in Afghanistan, 1960-1964 (°C)

Station [a]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North Salang	-10.3	-9.1	-4.9	-0.6	2.4	7.3	9.1	8.4	4.3	0.4	-4.3	-7.9	-0.4
Kabul	-2.4	1.5	6.6	11.4	17.3	22.8	25.2	24.3	19.6	12.4	4.6	-0.5	11.9
Kandahar	4.3	9.8	12.3	19.0	25.0	29.7	31.3	29.1	24.0	16.5	10.4	5.9	18.1
Herat	1.8	6.8	10.6	15.3	21.5	26.8	29.6	27.4	22.2	15.8	7.9	3.4	15.8
Maimana	3.1	6.3	8.7	13.6	18.9	24.5	27.0	24.6	19.0	13.2	7.7	3.3	14.2
Farah	6.0	10.7	16.1	20.4	25.8	31.4	34.1	31.2	25.6	18.5	11.5	7.8	19.9
Jalalabad	7.0	12.6	15.9	20.2	27.3	33.2	33.6	32.7	28.2	21.5	13.2	8.5	21.2
Kunduz	1.2	4.5	10.3	16.6	22.5	29.0	31.0	29.0	23.5	16.7	9.5	3.8	16.5
Mazar-i-Sharif	2.0	7.1	10.9	16.7	23.5	29.2	26.2	29.6	23.3	15.9	8.1	3.1	16.3

[a] Station locations and altitudes are presented in Figure 2-3.
Source: Central Statistics Office

Figure 2-3. Mean Annual Precipitation

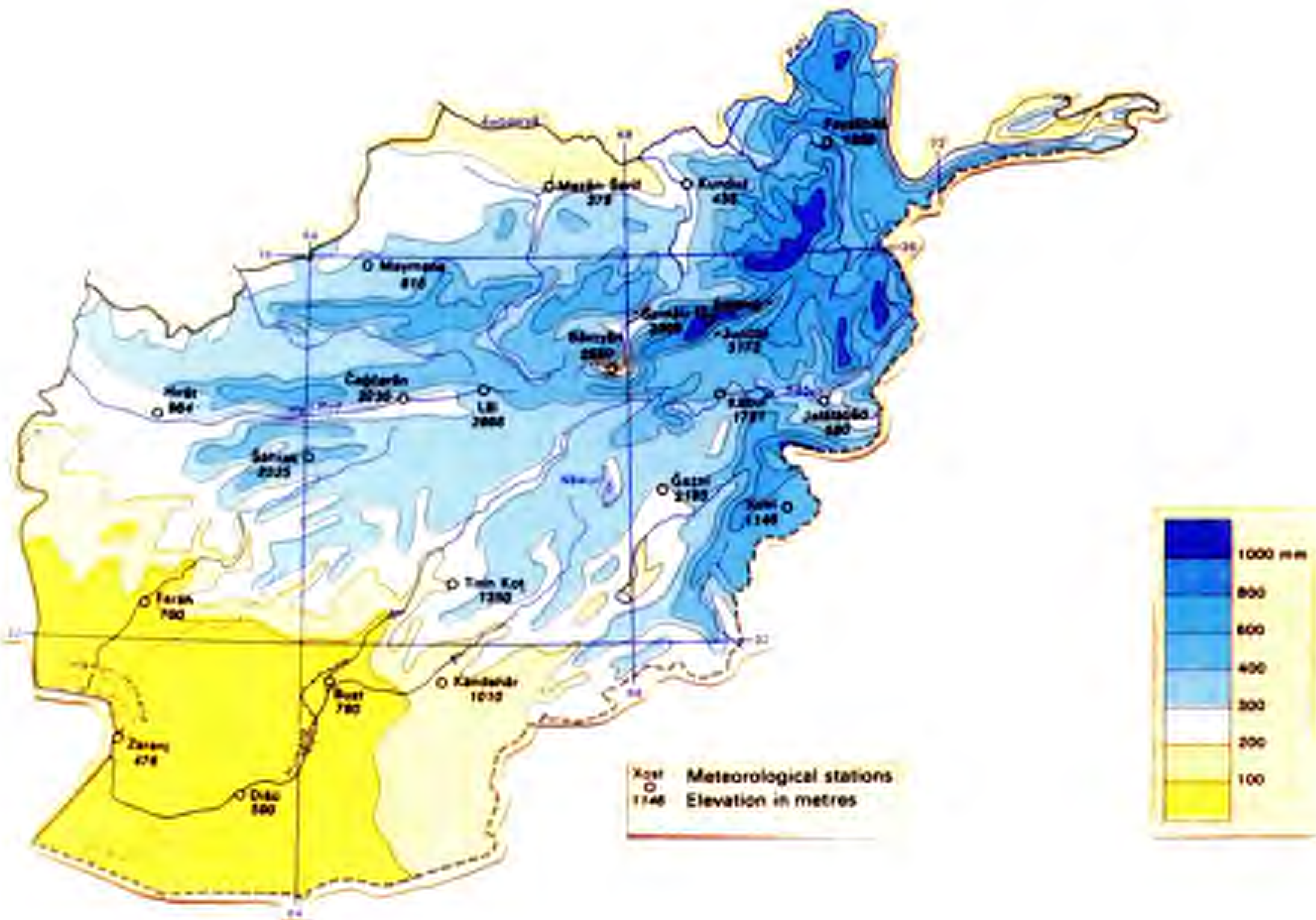

Table 2-2. Total Annual Precipitation Recorded at Selected Meteorological Stations in Afghanistan, 1964-1965 to 1975-1976 (mm)

Station	1963-1964	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	13-Year Average	High-Low Range [a]
South Salang	1272.1	1409.7	1083	1255.1	916.9	1045.9	840.3	818.1	1168.5	1167.5	824.0	917.9	813.2	1040.9	596.5
North Salang	1241.4	1444.5	1153.1	1125.1	1280.8	991.1	532	418	945	1209.5	759.9	749.9	999.1	988.4	1026.5
Kabul	431.1	426.5	318.6	326.3	325.8	312.1	200.4	233.3	392.3	381.8	181.5	290.9	276.4	315.2	249.6
Jalalabad	139	370.1	247.2	157.9	289.3	181.2	91	110.2	180.9	251.2	94.2	183.9	276.1	197.9	275.9
Baghlan	343.9	356.3	282.5	301.9	343.6	434.1	259.8	240.3	335.3	355.1	155.7	295.7	446	319.2	290.3
Khost	410.2	726.5	503.6	630.3	331.5	215.6	122.8	273.7	537.3	366	425.5	457.3	446.7	419.0	603.7
Kunduz	382.2	397.5	242.7	261.9	313.7	456	229.9	231.5	284.5	332.2	236.9	307.7	460.2	318.2	230.3
Kandahar	168.7	109.9	171.6	120.7	185.2	117	132.8	47.3	186.1	102.9	166.6	158.9	259.2	148.2	138.8
Herat	263.2	188.1	245.4	259.6	205.8	350.8	184.5	111.8	375.9	187.9	252	388.1	339.9	257.9	264.1
Ghazni	468	536.4	353.8	84.5	335.8	210.1	253.9	172.1	439.6	329.1	197.7	198.7	317.1	299.8	451.9
Maimana	396.3	369.7	226.5	319.9	396.8	563.5	293.7	200	437.4	375.4	261.2	237.5	463	349.3	363.5
Mazar-i-Sharif	207.1	194.3	130.4	182.7	212.1	357.4	161.1	130.9	213	257.9	123	244.8	205.2	201.5	234.4
Sheberghan	143.6	191.6	158.9	219.8	219.7	185.6	113.3	113.3	315.5	351.2	133.9	169.6	238	196.5	237.9

[a] Precipitation in highest year minus precipitation in lowest year

Source: Climatology Section, Afghan Air Authority and Central Statistics Office

Precipitation

Information on snowfall and rainfall in Afghanistan is neither as abundant nor as current as desirable. However, its scope and coherence are sufficient to permit generalization and explanation.

Available data suggest that approximately 236 billion m^3 of precipitation falls on Afghanistan in an average year.[4] Of this total amount, roughly 65 billion m^3 per year (or about 27.5 percent of the annual precipitation) flows through the country's principal river systems. The remainder falls on land surfaces where most evaporates, transpires through vegetation, is frozen in mountain glaciers, or is captured in aquifers far beneath the surface of the earth.

In general, precipitation varies with elevation, ranging from 50 to 100 mm annually in the southern plains to more than 1000 mm in the high mountains. Highest recorded rainfalls are at Salang in Parwan province, at an elevation of approximately 4000 m. Because of their strategic positions in the Central Mountains, data on snowfall gathered at the two Salang weather stations in Parwan province can provide important indications of water availabilities in much of the country. A small part of Badakshan province also has a relatively high rainfall.

The lowest rainfalls are in the lowlands southeast of Lashkargah and Farah, north of Mazar-i-Sharif and Sherberghan and west of Konduz and Baghlan, regions ranging in elevation from 200 to 500 m. A comparison of Figure 2-1, showing the general topography of Afghanistan, and Figure 2-3, showing the rainfall distribution, illustrates the relationship between elevation and precipitation.

Table 2-2 shows average annual precipitation for 13 selected meteorological stations in Afghanistan for a 13-year period, 1963-1964 through 1975-1976. Figure 2-3 shows the location and elevation of 20 weather stations and the geographical distribution of mean annual precipitation. The map shows 20 weather stations—certainly not a large number. Their distribution is

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[4]This rough estimate is based on average rainfall data gathered during the period between 1968-1969 and 1975-1976. The calculation was made as follows:

Average precipitation	0.362 m
Land area	65.3 million ha.
m^2 per hectare	10,000 m^2
Land area	652.6 billion m^2
Precipitation on land area	236.1 billion m^3
Of which, stream flow is	65.0 billion m^3
Stream flow as percentage of precipitation	27.54 percent

not sufficiently even to guarantee that data gathered at these stations can be safely extended throughout the country. Nevertheless, available data do provide a general indication of precipitation.

Table 2-2 shows the high degree of variability in precipitation from location to location. The range between high and low years of precipitation is wide. This range exceeded average yearly precipitation in 7 of the 13 stations shown in Table 2-2. Most agriculture in Afghanistan is supplied by river systems originating in the central mountains. Fluctuations in snow and rain at high altitudes affect irrigated agriculture throughout the entire country. At lower altitudes, precipitation adds to the supply of irrigation water and is critically important to rainfed agriculture. It is also important to rangeland and the nation's forests.

Seven of the 13 stations (North Salang, Khost, Kuduz, Kandahar, Herat, Maimana, and Sherbagan) experienced their lowest precipitation in the drought years 1969-1970 and 1970-1971 and 4 others (Kabul, Jalalabad, Baghlan, and Mazar-i-Sharif) in the drought year 1973-1974. One station (Baghlan) experienced its highest level of precipitation in 1975-1976, the same year that another (North Salang) had its lowest level. Figure 2-4 illustrates fluctuations in precipitation for selected stations at a variety of altitudes.

The majority of precipitation occurs from October through May; only 3 percent of the total annual precipitation occurs during the remaining months. Table 2-3 provides monthly precipitation data for selected stations. The rainy period coincides with the winter season. As a result, a significant amount of precipitation is snow, which accumulates at the higher elevations. This natural storage reservoir releases water later as temperatures begin to rise. Unlike man-made systems, however, where release of water is controlled, the natural system responds to daily fluctuations in ground and air temperatures, precipitation, sunshine, humidity, and other factors. A rapid increase in daily temperatures can bring a deluge of runoff, such as that experienced in the spring of 1991, which resulted in extensive damage to irrigation and other infrastructure.

Afghanistan is subject to substantial variations in precipitation and to periodic droughts and floods. The low annual precipitation, coupled with the large year-to-year fluctuations, forces almost all farmers in Afghanistan to rely primarily on surface and groundwater sources to supply water to the major portion of their crops.

It has been estimated that, in a given 10-year period, 4 years will produce average precipitation, 3 significantly above normal and 3 significantly

Chapter 1

INTRODUCTION AND EXECUTIVE SUMMARY

Introduction

The objectives of this report are to

1. Examine technical, economic, cultural, and institutional constraints on water availability in Afghanistan;

2. Anticipate the character and, where possible, the magnitude of particularly severe problems likely to be created by refugee return;

3. Identify measures that could mitigate existing and anticipated problems; and

4. Suggest activities to prepare the Mission to contribute to the resolution of water constraint problems posed by refugee return.

Following the introduction and executive summary in this chapter, Chapter 2 presents information on Afghanistan's water resources. Past water development projects and strategies are reviewed in Chapter 3. In Chapter 4, a constraint analysis is presented. Chapter 5 presents recommendations concerning priority water development projects and other activities that A.I.D. and other donors should consider financing.

Executive Summary

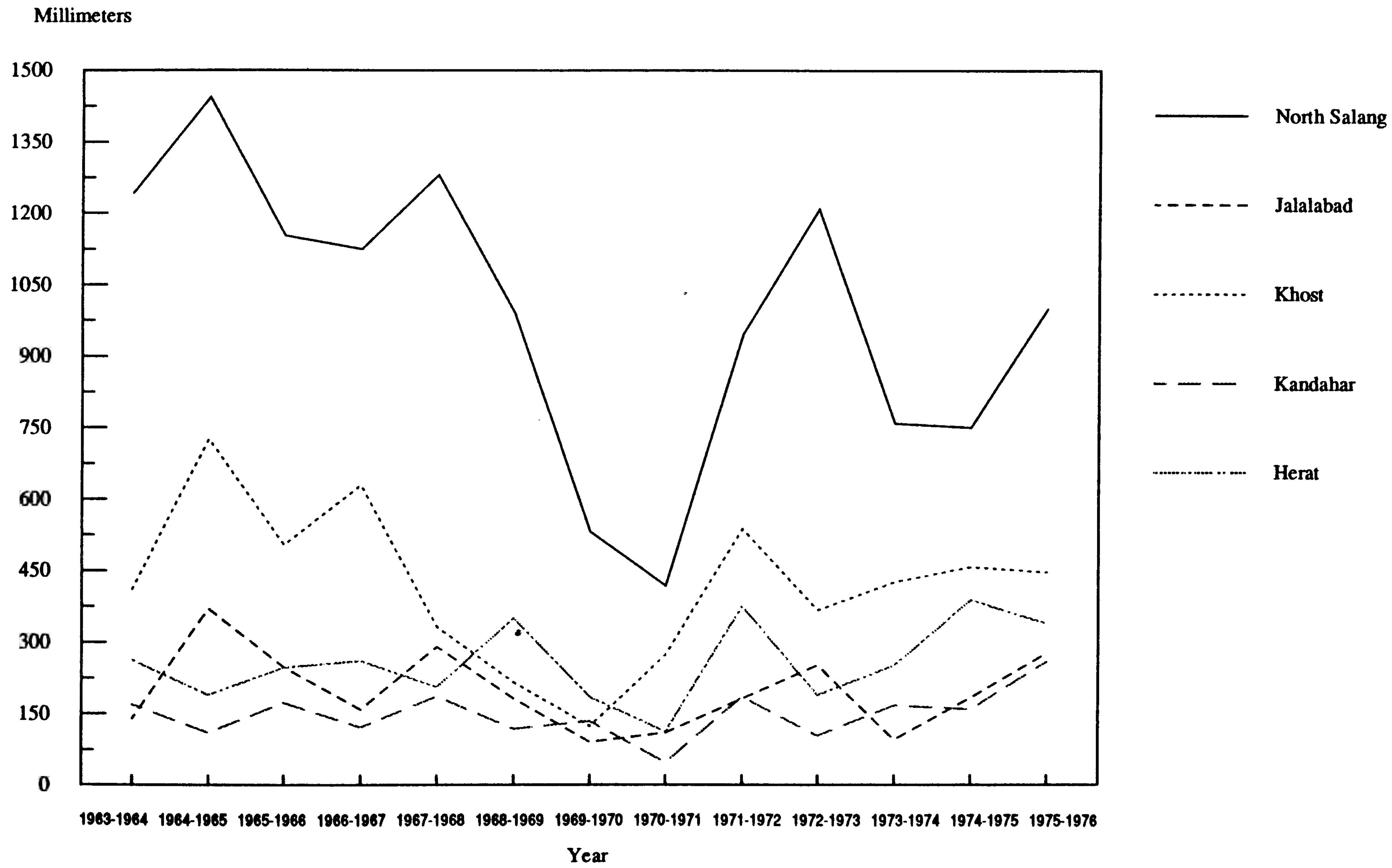
The lack of water as an input to agriculture is likely to constrain rural resettlement and agricultural development for many years after solutions to Afghanistan's political troubles have been identified. A number of measures can be adopted to prevent further deterioration of the country's existing irrigation systems and to improve the productive capacity of watered land in

Table 2-3. Mean Monthly Precipitation for Selected Stations (mm)

Station [a]	Period or Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Annual
North Salang	1962-1973	91.4	155.5	192	217.5	139	9.8	9.3	1.3	9.3	37.2	58.5	123.5	1044.3
Kabul	NA	42	50	61.4	69.5	25	4.5	4.6	5.4	1.8	8.8	13.6	34.5	321.1
Kandahar	1940-1960	57.1	37.9	32.2	11.7	6.5	0.1	3.3	0.1	0	0.1	5.3	21.7	176
Jalalabad	NA	5	14	94	25	14	0	8	20	45	0	0	12	237
Kunduz	1959-1973	41.22	56	71	55	32.3	0.6	1.7	0.3	0.1	7.7	21	24	310.92

[a] Figure 2-3 presents station locations and altitudes.
Note: NA denotes information not available.
Source: Childers, D. Compilation of streamflow (and other) records, Helmsand River Valley and adjacent areas, Afghanistan, 1974.
Fau. Survey of Land and Water Resources Afghanistan, Volume V, Water Control Report No. FAO-SF9/AFG, 1975.
Nuzar, A. Risk Avoidance in the Operation of a Water Supply System, Dissertation, Colorado State University, 1979.

Figure 2-4. Yearly Variations in Precipitation for Selected Stations: 1963-1964 to 1975-1976



Source: Table 2

below normal.[5] However, during some periods, very wide swings in precipitation patterns predominate.

Table 2-4 shows the fluctuating pattern in overall average amounts of annual precipitation for the 7-year period from 1968-1959 to 1974-1975:

Table 2-4. Annual Variations in Precipitation

Year	Yearly Average (mm)	Percentage Variation from 7-Year Average in Precipitation
1968-1969	417.0	18.5
1969-1970	262.7	-25.4
1970-1971	238.5	-32.2
1971-1972	447.1	27.1
1972-1973	435.6	23.8
1973-1974	293.2	-16.7
1974-1975	369.3	4.9
7-Year Average	361.8	0.0

Source: Central Statistics Office.

A serious drought occurred in 1969-1970 and 1970-1971, resulting in thousands of deaths. A less-serious period of low precipitation took place in 1973-1974. A drought in 1984, compounded with the complications of the war, caused considerable suffering.

Major flooding in 1991 occurred as a result of heavy snows in the winter of 1990-1991 and heavy rains in the spring of 1991. The Helmand Valley experienced perhaps its heaviest flood in 100 years during the spring of 1991.

Fluctuations in precipitation from year to year can significantly affect Afghanistan's economy, as described later in this report.

Glaciers and Snow Pack

Figure 2-5 presents the relationship between glaciation and snow cover and other types of natural landscape in the northeast corner of Afghanistan. Figure 2-6 shows the important region of Afghanistan served by rivers supplied by water mainly from the glacierized region.

[5]Street, Jones, et al., *A Feasibility Study of Wheat Stabilization and Marketing Scheme for Afghanistan Incorporating a Strategic Reserve.* Tropical Products Research Institute Report No. R662, London, 1977.

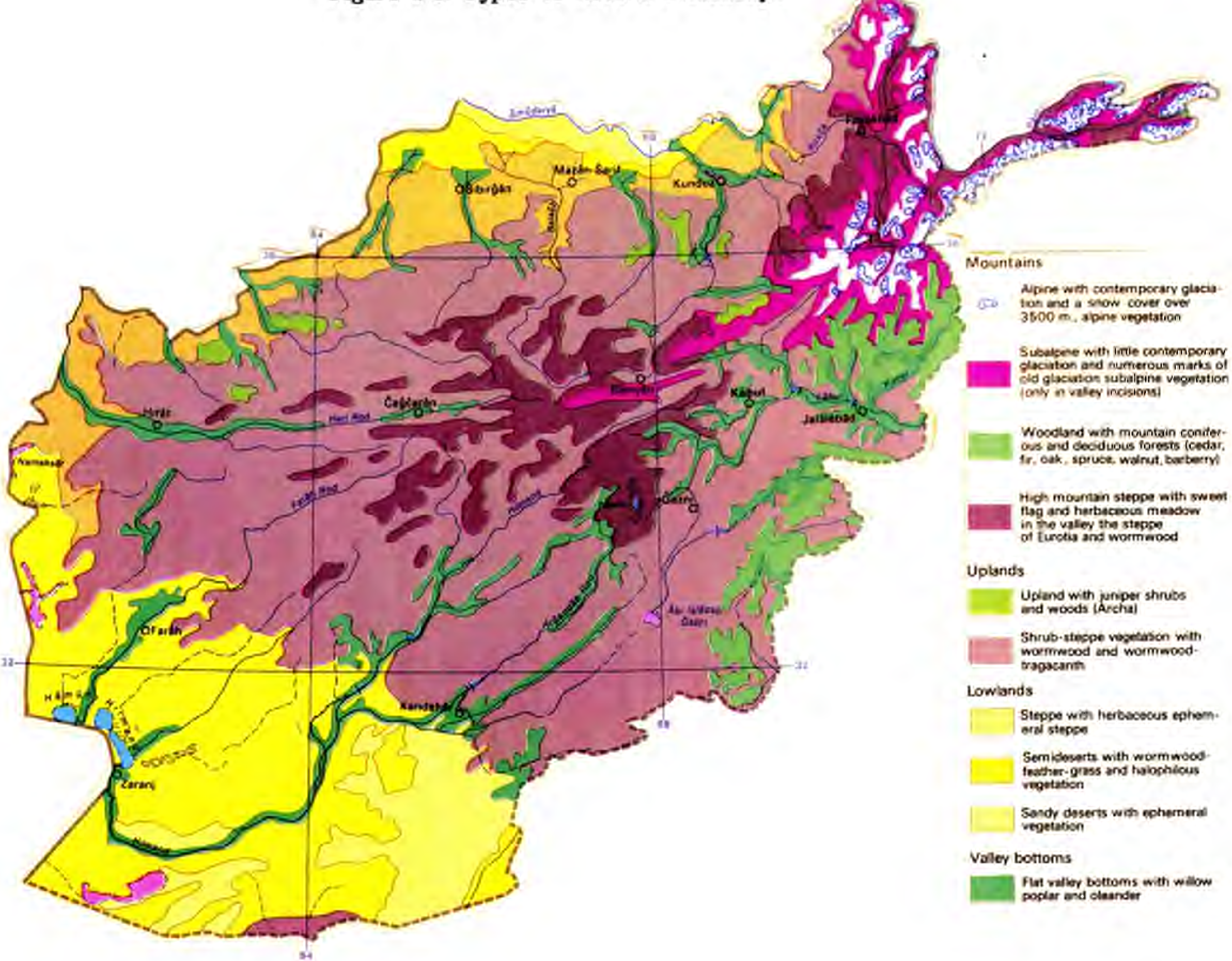
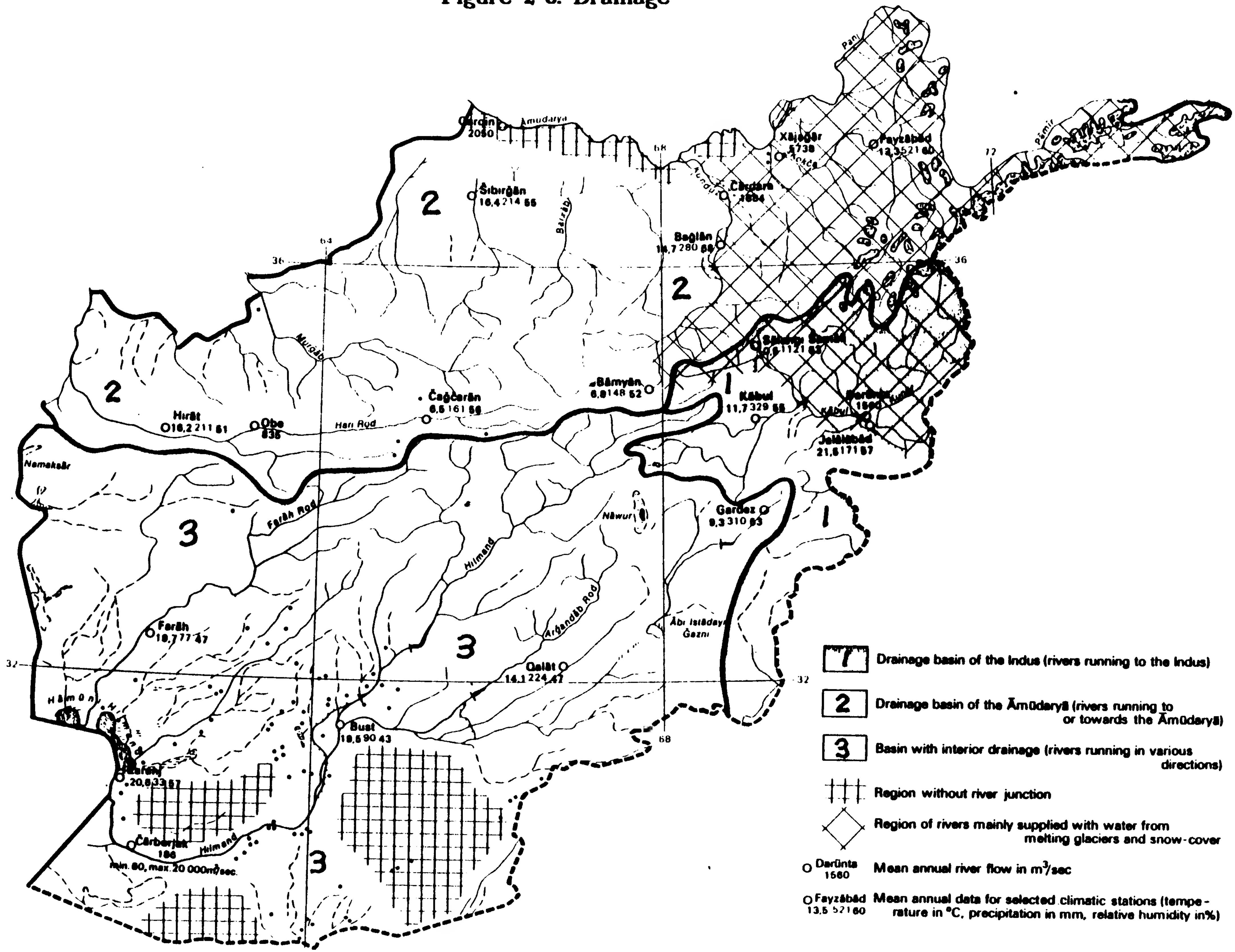


Figure 2-5. Types of Natural Landscape

Figure 2-6. Drainage



Source: National Atlas of the Democratic Republic of Afghanistan. Warsaw: GEOKART, 1985.

Like long-term assets on a balance sheet, glaciers and heavy high-altitude accumulations of snow last from year to year. In theory at least, these long-lasting accumulations represent intertemporal "stocks" of water that can function as long-term assets—growing in size in years of relative cold temperatures and heavy snows and shrinking in hot and dry years. In practice, data on and analysis of glaciers and high altitude snows of Afghanistan are very limited.

Approximately 4,000 km^2 of Afghanistan's surface area is glacierized.[6] This rough projection is based on an estimate that the country contains more than 3,000 mostly small, debris-covered glaciers with a mean area of about 1 km^2 each and about 15 large glaciers with a mean area of about 50 km^2 each. The glacierized surface has been rounded to the nearest 1000 km^2. In the 1970s, as part of a National Atlas of Afghanistan project, the University of Nebraska at Omaha (UNO) began work for a glacier inventory. This work was financed by A.I.D. under a contract with UNO, who provided assistance to Kabul University. Some 3,150 glaciers were inventoried on 1:100,000 scale maps. Most of these were small glaciers that occur in cirques or simple basins. The largest and longest glaciers are located in the narrowest parts of the entrance to the Wakhan Corridor in the extreme northeast of Afghanistan. Rock glaciers are common and mark an extended occurrence of periglacial permafrost in mostly arid mountain regions.

Table 2-5 shows the status of the UNO glacier inventory work shortly before UNO's work was terminated in 1978.[7] In a World Glacier Inventory Workshop in September 1978, Shroder reported a number of problems, including difficulties in defining drainage basins because so many large irrigation ditches have diverted water over natural divides. Other problems included orientation of glaciers with multiple source regions; limitations of photography, maps, and ground surveys; and snow fields located above glaciers.

Shroder's 1978 review of the literature and UNO findings available at that time indicates a general retreat of Afghanistan's glaciers. Shroder did not exclude the possibility that further detailed field study might reveal a pattern of fluctuating contraction and expansion such as that believed to exist in the Soviet Union. He concluded

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[6]W. Haeberili et al., *World Glacier Inventory: Status 1988.* World Glacier Monitoring Service, International Association of Hydrological Sciences, 1989, pp. C39-C40.

[7]J.F. Shroder, Jr., "Special Problems of Glacier Inventory in Afghanistan," *Proceedings of the Workshop at Riedalp, Switzerland, 17-22 September, 1978.* Surrey, United Kingdom: International Association of Hydrological Sciences, 1980, pp. 149-154.

Taken as a whole, however, the limited data available for Afghanistan suggest regional recession of the glaciers there. If this suggestion is confirmed by further research, the implications for the future of this arid country are very serious indeed.[8]

Table 2-5. Afghanistan Glacier Inventory: Drainage Basins and Status

Basin	Status of Work
Turkestan endorheic drainages	
Warduj	Incomplete
Munjan	Incomplete
Upper Kokcha	Incomplete
Anjuman	Incomplete
Darang	Complete—6 glaciers
Darrah-i-Kul Ab	Complete—104 glaciers
Darrah-i-Sabz	Complete—54 glaciers
Darrah-i-Jaway	Complete—113 glaciers
Maynay	Complete—91 glaciers
Yarkh	Complete—65 glaciers
Shiwa	Nearly complete
Chakmaktin Kol	Incomplete
Upper Abi-Panj	Incomplete
Pamir	Complete—174 glaciers
Wakhan	Incomplete
Taliquan	Incomplete
Chal Bangi	Incomplete
Andar Ab	Complete—80 glaciers
Surkh Ab	Complete—73 glaciers
Indus River basin drainages	
Alishang-Alingar	Complete—178 glaciers
Ghorband-Panjsher	Complete—262 glaciers
Pec	Incomplete
Upper Kabul	Incomplete
Afghan-Iran plateau drainages	
Upper Helmand	Complete—7 glaciers

Source: Shroder, J.F., Jr. "Special Problems of Glacier Inventory in Afghanistan," in *Proceedings of the Workshop at Riedlap, Switzerland, September 17-22, 1978*. United Kingdom: International Association of Hydrological Science, 1980, p. 152.

It is possible that retreat of some Afghan populations to remote mountain regions during the Soviet invasion and fallout of ash from the oil fires in Kuwait may have had some negative effects on mountain ecology, snow cover, and glaciation.

The Earth Satellite Corporation, a subcontractor to DAI (the prime contractor for the Agricultural Support Services Program) has roughly

[8] J.F. Shroder, Jr. "Special Problems of Glacier Inventory," pp. 152-153.

predicted snowmelt runoff on the basis of estimates of snow depths and areal coverage.

During the winter season, satellite infrared images are obtained every day. Cloud-top temperatures (which are correlated to amount of precipitation) are obtained from the imagery and used to estimate precipitation on the ground. Available ground-temperature data are used to develop a relationship between elevation and temperature in the various regions. This relationship identifies regions that receive snow and those that receive rain. The model keeps track of snow accumulations throughout the season. On clear days, satellite imagery is used to verify the snow-level predictions and to provide information on the areal extent of snow coverage.

A simple ratio of snow depth to water content is used to roughly estimate the total water volume contained within the snowpack. Gross watershed delineations have been used to estimate potential runoff volumes. At this time, no effort has been made to predict the rates at which the snow melts.

Satellite imagery and other data collection efforts indicated last year that an unusual amount of snow had accumulated in the Hindu Kush during the 1990-1991 winter season. Interpretation of the satellite imagery revealed both the heavy snowfall accumulations and the unusually long stormy period during the late winter and early spring months that 'precipitated' the large destructive floods on many rivers. The high runoffs were expected by Earthsat, who were keeping track of the weather in Afghanistan.

Designation of Drainage Regions

Although Afghanistan's drainage regions may be described at various levels of detail and grouped in a variety of ways, the country's rivers are typically divided among four major drainages: the Amu Darya, the Hari Rud, the Helmand-Arghandab, and the Kabul basins. The Amu Darya, draining the northern slope of the Hindu Kush, includes the following major rivers: the Kokcha, the Konduz-Khanabad, the Tashkurgan, the Balkh, the Sarepul, and the Shirin Tagab. The Hari Rud, draining the northwest portion of the country includes the Kowgon and Murghab rivers. The rivers of the Helmand Valley, the largest drainage basin within Afghanistan, drain the southwestern flank of the Hindu Kush and include the Tirin, the Musa Qala, the Ghazni, the Arghastan, the Arghandab, the Adraskand, the Farah, and the Khash as well as the Helmand itself. The Kabul River, a major tributary of the Indus, drains the eastern part of the country. Chief rivers within the Kabul Basin include the Panjsher, the Laghman, the Kunar, and the Lowgar. Outside the Kabul drainage, also draining to the Indus River, are the Kaitu, the Margha, and the Gumal rivers.

Figure 2-2, presented earlier Chapter 2, is a modified form of a map developed by Louis Dupree showing a typical four-region definition. Dupree's classification has been altered; the boundary of his Kabul System was moved to the south to include much of Paktya and Paktyka, and the region was renamed to indicate that it is a part of the Indus System. As a result of the adjustment, System 4 on the original Dupree map conforms with the corresponding portion of the GEOKART map in Figure 2-6, which shows the "drainage basin" of rivers running to the Indus, and with the findings of this study. The other significant difference between Figure 2-2 and Figure 2-6 is that the GEOKART map shows a single region in the north and northwest of the country (Dupree's Amu Darya and Hari Rud River Systems), referred to as a drainage basin of rivers running to or toward the Amu Darya. This report agrees with the treatment on Dupree's original map, rather than the one in Figure 2-6. This large northern region should be considered to contain two principal river systems: the Amu Darya System and the Hari Rud System, rather than as a single basin.

This report undertakes a much more detailed level of analysis, distinguishing 37 individual drainage basins, which were in turn combined into nine drainage regions. These nine drainage regions relate to the river systems shown in Figure 2-2 as follows:

Drainage Region	*Principal River System*	*Main Provinces*
Northeastern	Amu Darya	Badakshan, Bamian, Baghlan, Konduz, Takhar
Northern	Amu Darya	Samangan, Balkh, Jowzjan, Faryab
Northwestern	Hari Rud	Badghis, Herat, Ghor
Western	Helmand-Arghandab	Farah
Southwestern	Helmand-Arghandab	Nimroz
Southern	Helmand-Arghandab	Helmand, Qandahar, Oruzgan, Zabul
Southeastern	Indus	Paktya, Paktyka
Eastern	Indus	Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar
Central	Self-contained	Ghazni

Figure 2-7 shows the locations of each of these nine drainage regions, as well as the 37 drainage basins. Drainage region boundaries do not, of course, conform to the political borders of provinces. Provincial designations are provided to assist the reader in locating these basins. In Chapter 4, provincial designations relate data on water flows to data on agriculture.

the short run. However, policymakers should be wary of short-term solutions that encourage rural resettlement of refugees in times of bountiful precipitation without taking sufficient account of the inevitable months and years of drought. For the long term, Afghanistan requires a water development strategy that will accommodate needs for hydroelectric energy production and urban water supply, as well as for irrigation water for agriculture.

Water is the most essential input for successful farming by returning refugees—particularly in years of limited snowfall and rainfall. Ensuring adequate water for the irrigated land necessary for an expanded rural population will necessitate rehabilitation of existing irrigation systems, completion of modern irrigation projects that were cut short by conflict, creation of new physical infrastructure, and, quite possibly, resettlement of some refugees in regions other than those of their origin.

Afghanistan is often characterized as a dry or arid country. Although this perception is accurate, the average annual precipitation is sufficient to support irrigated agriculture for a significantly expanded rural population. Afghanistan receives rain and snow equivalent to about 236 billion m^3 of water in an average year. About 65 billion m^3 of water flow in Afghanistan's rivers and streams. Water constrains Afghanistan's rural economy in combination with other factors such as geography, topography, temperature, winds, soil conditions, farm technology and practices, and traditional human behavior—factors that must be taken into account in a realistic assessment of constraints. The difficulty is created by the cost of irrigation system improvements and human technical and managerial capabilities required to operate improved systems effectively.

Afghanistan's topographic profile resembles a peaked and rumpled hat with a very irregular brim. Four main river systems flow down from Afghanistan's mountainous center, across its lowlands, and into deserts or adjoining countries. Regions above 14,000 ft (which receive heavy snow) and those above 4,000 ft (which receive a combination of snow and rain) supply most sections of the country with water during the spring and early summer months.

Most water carried by the country's four principal river systems originates in Afghanistan's central mountains. The heaviest flows occur in the spring and early summer. In the late summer and early winter, river flows are sharply reduced and some cease altogether. Badakshan, Kunar, and Takhar provinces in northeast Afghanistan contain regions of glaciation. The glaciers represent a long-term ecological asset that can stabilize water supply within and between years. The glaciers lend a steadiness to streamflows in the northeastern region of the country that does not exist elsewhere in Afghanistan.

Brief descriptions of each of the nine drainage regions and their relationships to their river systems follow.

The Amu Darya System (Two Drainage Regions)

The Amu Darya, Afghanistan's largest river, runs for approximately 2,500 km from its source in the Pamirs to the Aral Sea in the Commonwealth of Independent States (CIS). The Amu Darya defines most of the northern boundaries of the Northeastern Drainage Region and the Northern Drainage Region and much of Afghanistan's northern border with the CIS. As it rises in the Pamirs, it is called the Ab-i-Wakan. After the Ab-i-Wakan joins the Ab-i-Pamir (a tributary that also defines the most eastern section of Afghanistan's northern border with CIS for a short distance), it becomes the Ab-i-Panja. After the Kowkcha River joins the Ab-i-Panja, the river is known as the Amu Darya until it flows into the Aral Sea.

The Amu Darya flows in rapid torrents in its upper course, carrying along gravel and boulders. After it passes the mouth of the Kowcha, the Amu Darya becomes calmer. The flow diminishes in the central and lower portions of the river because of evaporation and extensive use of water for irrigation.

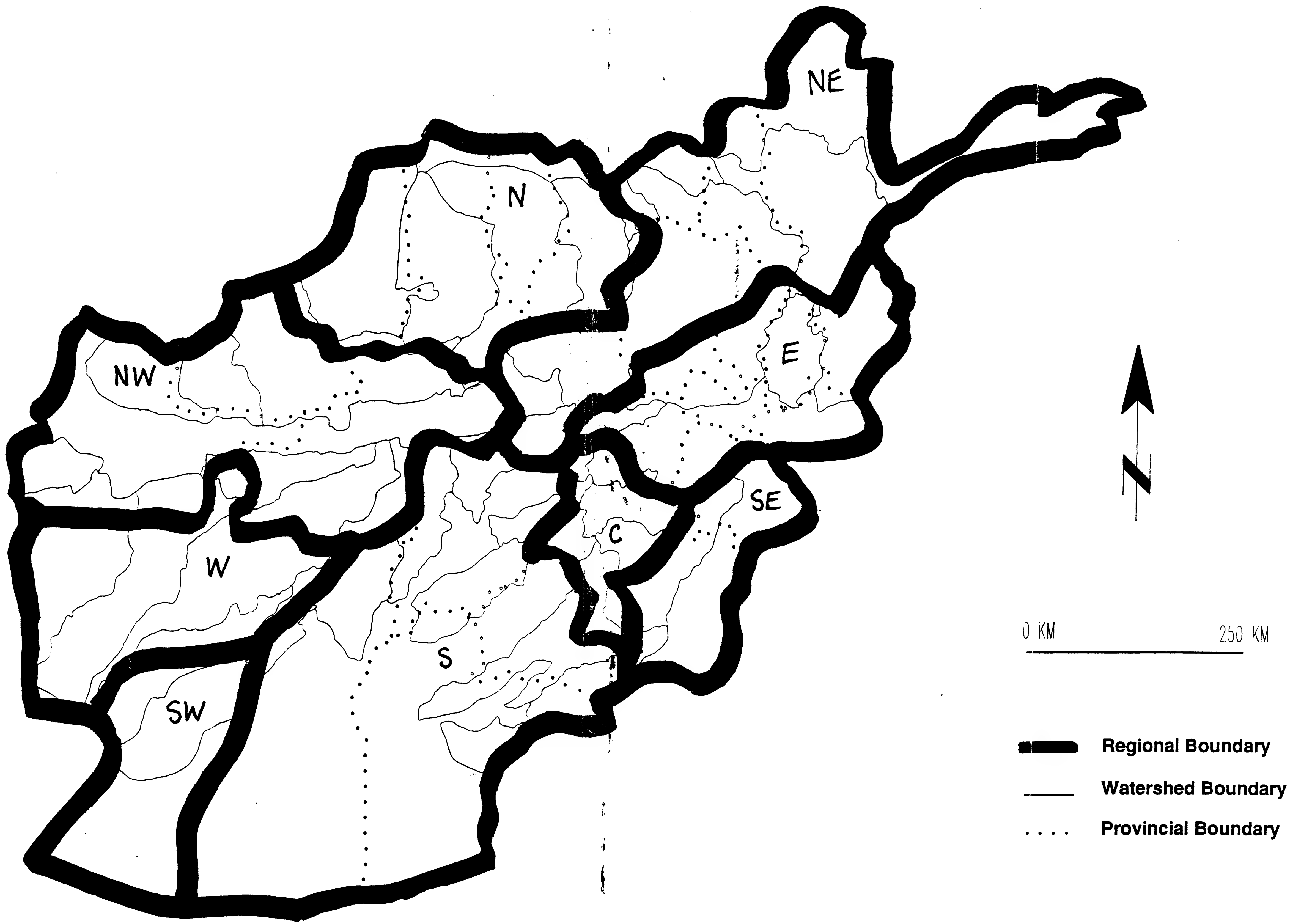
From a strictly technical point of view, a large part of the Amu Darya's drainage area is in the CIS. This study examines only those portions that are in Afghanistan. Although most of the Amu Darya's flow originates in drainages in the former Soviet Union, a significant amount of the total runoff—approximately 25 to 30 percent—is contributed by the Afghanistan portion of the basin. It should be noted, however, that the CIS states in Central Asia suffer water shortages. The level of the Aral Sea is reported to be declining rapidly.

Northeastern Drainage Region (Amu Darya System)

The Northeastern Drainage Region roughly corresponds to the provinces of Badakshan, Bamian, Baghlan, Konduz, and Takhar. Major Afghan tributaries contributing to the flow of the Amu Darya in this region include the Wakhan, the Kowkcha, the Khanabad, and the Konduz with a combined total drainage area of 91,000 km^2, about 19 percent of the total area of the country. Combined total annual flow of these tributaries is approximately 11,910 million m^3, or about 20 percent of the country total.

The Kowkcha rises in the eastern flank of the central mountains and runs for 320 km north and then west through Badakhshan and Takhar provinces before joining the Amu Darya. West of the Kowkcha, the Amu Darya is joined by the 480-km long Konduz. In its upper regions, the Konduz

Figure 2-7. Regional, Provincial, and Watershed Boundaries



is known as the Bamian Rud and the Surkhab, becoming the Konduz when it is joined by the Andarab at Doshi. The Khanabad River is the last major tributary of the Konduz to be intercepted before the main river empties into the Amu Darya.

The Konduz River Valley is one of the most productive and relatively developed regions of the country. The main valley is defined by the confluence of the Andarab and Surkhab Rivers, which form the Konduz at the upper end of the valley, and the confluence of the Konduz with the Amu Darya, at the lower end. The valley is completely contained within the provinces of Konduz and Baghlan. Before the war and under normal climatological and hydrological conditions, food grains produced in the Konduz River basin were in excess of local needs, and the excess was shipped to Kabul and other parts of the country where shortages occurred.

A relatively small proportion of the total regional area irrigated (only 4 percent) is supplied by groundwater.

Precipitation levels vary within the region. The Wakhan corridor, the narrow strip of Afghanistan dividing China from Pakistan (originally India), has the lowest precipitation with less than 10 cm annually. Precipitation totals in the low regions of the Amu Darya valley are slightly greater at 12 to 15 cm per year, while the more populated regions, including Baghlan and Konduz, receive 25 to 40 cm annually. The Salang Pass, which breaches the range separating the Kabul and Amu Darya drainages, receives the highest precipitation with more than 100 cm annually. The northern region rarely experiences the Indian monsoons that affect the eastern and southeastern regions.

Northern Drainage Region (Amu Darya System)

The Northern Drainage Region roughly corresponds to the region covered by the provinces of Samangan, Balkh, Jowzjan, and Faryab. West of the Konduz River drainage of the northeastern region, several smaller rivers—the Kholem, the Balkh, the Sarepul, and the Shirin Tagab—flow from the northern slopes of the Hindu Kush toward the valley of the Amu Darya without ever reaching it. Altogether, these waterways drain an area of about 80,330 km^2, about 12 percent of the total land area of the country. The sum of annual flows of these tributaries is approximately 4,970 million m^3, about 8 percent of the total country river flow.

The Kholem flows north from the Hindu Kush through a succession of narrow, cliff-walled gorges into the Turkestan plains. The Balkh River originates in the Band-e Amir lakes in the central mountains and gathers tributaries that drain the western half of the northern plateau. The Balkh is drained of its waters when it reaches the Ishkabad canal system of the

Turkestan Plain, which is made up of 20 irrigation canals.[9] Like the Balkh River, the Sarepul flows north and is drained by irrigation before reaching Shebargan. The Shirin Tagab river also feeds a 28-canal irrigation system, the Mirabad, before vanishing in the northern plain.

Groundwater contribution to irrigation in the northern region is minimal; only 5 percent of the total irrigated land is supplied by underground water.

Precipitation patterns of the northern region resemble those in the northeastern region—low regions adjacent to the Amu Darya valley receive between 12 and 15 cm per year; the higher, populated regions such as Maimana, Sherberghan, and Mazar-i-Sharif receive between 20 and 35 cm annually; and the mountain regions receive 30 to 60 cm per year.

The Hari Rud System
(One Drainage Region)

As noted earlier, GEOKART's National Atlas of the Democratic Republic of Afghanistan treats the Hari Rud and Murghab rivers in northwestern Afghanistan as part of a common drainage basin of rivers running into or toward the Amu Darya. It is certainly true that the rivers of the Hari Rud system (the Hari Rud and the Murghab) enter the CIS and then flow northward in the general direction of the Amu Darya. It is also true that a number of rivers in Dupree's more restricted definition of the Amu Darya system, drain toward but never reach the Amu Darya (essentially because of the high consumption of irrigation water by farmers along these streams). However, the Hari Rud and the Murghab rivers stop well short of the location of the Amu Darya in the CIS, and it is doubtful that the shortfall can be attributed solely to irrigation.

Northwestern Drainage Region
(Hari Rud River System)

The Northwestern Drainage Region roughly corresponds to the provinces of Herat, Badghis, and Ghor. The Hari Rud and Murghab Rivers, principal streams of the northwestern region, drain approximately 85,800 km^2, or about 13 percent of the land area of the country. Total flow for the region is approximately 3,060 million m^3 per year, about 5 percent of the total flow within the country.

The Murghab rises in a western valley of the Hindu Kush, flows through Badghis, and is joined by its tributaries, the Kushk and Qala Now, north of Afghanistan, before disappearing in an oasis in the former Soviet Union. The river is more than 800 km long; more than half is in Afghanistan.

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[9]*Afghanistan: The Northern Provinces,* The Orkand Corporation, 1988.

The Hari Rud, one of four major river systems in Afghanistan, rises in the high central plateau and flows west toward Iran. When it reaches Iran, it turns north, forming the border between the two countries. North of Afghanistan, the river forms the boundary between the former Soviet Union and Iran before disappearing in the desert of Turkmen. The Kowgon River is the only major tributary of the Hari Rud, rising to the south of the main river and flowing almost parallel to it before joining it near Marwa.

Groundwater supplies approximately 14 percent of the total irrigated land in the region. The highest proportion of usage is in the provinces of Badghis and Ghor where 41 and 53 percent of the area irrigated (31,000 and 31,300 ha., respectively) is supplied by groundwater. Only 2 percent of irrigated land is supplied by groundwater in Herat province (3,300 ha. of 166,500 ha. total irrigated land.)

The lower parts of the region, including much of the Hari Rud valley and the city of Herat, receive approximately 20 to 30 cm of rainfall annually. Average annual rainfall in Herat is 24 cm. The upper valleys and mountains receive most rainfall in the region with annual totals of between 40 and 60 cm.

The Helmand-Arghandab System (Three Drainage Regions)

The Helmand-Arghandab System consists of three drainage regions that drain into the Sistan Depression. Shallow lakes lie in the Sistan Depression along Afghanistan's southern and western borders. Several of these lakes extend into Iran.

Southern Drainage Region (Helmand-Arghandab System)

The Southern Drainage Region roughly corresponds to Helmand, Qandahar, Oruzgan, and Zabul provinces. The southern region contains the entire Helmand Valley Project, a large-scale development carried out on both the Helmand and Arghandab Rivers with the assistance of a private U.S. firm and with both indirect and direct U.S. government involvement from 1946 to 1979. Although numerous problems with drainage, salinization, and settlement of nomads were experienced over the course of project implementation, the total area under cultivation was expanded from 77,000 ha. to 145,000 ha. during the period of direct government involvement.

The valleys of the Helmand-Arghandab river system, located in the southwestern portion of the country, constitute the largest watershed in Afghanistan, covering about 201,100 km^2, or about 30 percent of the total land area of the country. Runoff generated by this basin, approximately 8,150 million m^3 per year, accounts for about 14 percent of the country's total

runoff. Most of the river system's streamflow accumulates in the headwater regions, either from rainfall at the intermediate elevations in the winter and spring season or from snowmelt from higher elevations in the late spring and early summer. Lower sections of the basin are desert regions contributing little or no flow except during flash floods—which are usually the result of short-duration, intense local storms.

The Helmand River, on average, accounts for about 80 percent of the basin's total flow. From its origin in the Hindu Kush just south of Kabul, it flows southwesterly for more than 500 km before its confluence with the Arghandab. From here the river continues its southwesterly course flowing ultimately into the desert and marshes along the Iranian border.

Within the region, groundwater supplies approximately 30 percent of the total land area irrigated each year. Highest usage is in the provinces of Uruzgan and Zabul where groundwater is used to irrigate 60 and 40 percent of the total irrigated land area, respectively, in each province.

Precipitation in the valleys is low, varying from about 100 to 200 mm annually. Precipitation in the central section of the basin, near Lashkargah, averages about 130 mm. Near Kandahar, the principal city of the basin, precipitation is slightly higher, at about 180 mm annually. Near Chakhansur, in the lower part of the basin, precipitation averages about 76 mm each year. Rainfall supplies only a marginal part of the moisture required for spring crop production. Water supply for summer and fall crops must come from irrigation.

Southwestern Drainage Region
(Helmand-Arghandab System)

The Southwestern Drainage Region corresponds roughly to Nimroz province. The Khash and Khuspas Rivers, with a combined drainage area of approximately 30,200 km^2, about 5 percent of the total land area of the country, are the primary sources of water supply for the region. Combined annual flow for the two rivers is approximately 2,250 million m^3, about 7 percent of the country's total. The Helmand River flows through the southern part of the region, supplying a small agricultural region before emptying into the marshes of the Hamuni Helmand.

Groundwater is essentially not used in the region; only 1 percent of the irrigated area is supplied by underground water.

Western Drainage Region
(Helmand-Arghandab System)

The Western Drainage Region corresponds roughly to the area of the province of Farah. The Farah and Adraskand Rivers are the principal streams

of the region, draining about 66,300 km^2 or 10 percent of the country as a whole. The basin generates about 3,600 million m^3 per year, accounting for about 6 percent of total annual runoff in Afghanistan. Only the upper reaches of these streams are perennial, and during most years, much of the available streamflow is completely used for irrigation.

Groundwater usage in the region is quite high; approximately 41 percent of the irrigated area is supplied by underground water.

Rainfall in the region is extremely low with average annual precipitation about 100 mm and lower rainfall common over much of the basin. Only the upper regions southeast and east of the two main rivers experience higher levels of rainfall—approximately 300 mm to 400 mm.

The Indus System
(Two Drainage Regions)

The Indus System is composed of two drainage systems: (a) the Eastern Drainage Region, roughly corresponding to the Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar, and Nangarhar provinces and (b) the Southeastern Drainage Region, roughly corresponding to the Paktya and Paktyka provinces.

The Kabul River system, the larger of the Indus River tributaries, drains only 8 percent of the country, but generates almost 40 percent of its total runoff. Upper reaches of the Kabul basin are located in some of the country's highest precipitation regions and runoffs are augmented by the melt of glacial snow pack and ice. Dependable water supply has made this region attractive to farmers for centuries.

Southeastern Drainage Region
(Indus System)

The Gumal, Khost, and Sardeh rivers are the primary sources of water supply for this region, having a combined total annual flow of approximately 1,260 million m^3, about 2 percent of the country's total runoff. The total drainage area for these three river basins within Afghanistan (the Gumal and Matun river basins extend into Pakistan) is 30,900 km^2. Like the Kabul River, the Gumal and Matun drain into the Indus and ultimately to the sea. To the west, the Sardeh drains a closed basin, emptying into Ab-i-Istada, a salty lake with no outlet.

Groundwater supplies approximately 28 percent of the total area irrigated, or about 20,400 of the 72,400 ha. under irrigation. Most of the rainfall in the southeastern region falls in the winter and early spring. A shorter period of rainfall occurs occasionally in the late fall when the southwest

monsoon extends west of the Indus, affecting the margins of eastern Afghanistan.

Eastern Drainage Region (Indus System)

The Kabul and its tributaries drain about 52,000 km^2, or approximately 8 percent of the total land area of Afghanistan. Combined flows of all the major tributaries and the Kabul River average about 23,100 million m^3 annually, or about 39 percent of the total surface water supply of the country.

Two of the easternmost rivers of the system, the Laghman and the Kunar, drain the high mountains of the Hindu Kush, benefiting not only from snow melt runoff but also from glacial runoff. These large tributaries provide the Jalalabad region with one of the most reliable water supplies in the country. The western and northern tributaries of the Kabul, Lowgar, Ghorband, and Panjsher are more affected by seasonal and annual fluctuations in precipitation. These streams run high during the spring and early summer months but drop quickly once the snowmelt is complete.

The headwaters of the Kabul River are about 80 km west of the capital in the north-central portion of the Wardak province. From here, the Kabul flows east to Jalez, adding the waters of the Sanglakh Valley before encountering the town of Kowt-e-Ashrow. From Ashrow, the river flows southeasterly to Sar-i-Pul and from there north-easterly to the capital. From Jalez to Sar-i-Pul, the river valley is wide enough to permit substantial irrigated cultivation.[10] East of Sar-i-Pul, the river valley narrows until reaching the Kabul plain where substantial cultivated areas are established.

Immediately east Sar-i-Pul, the Kabul and the Lowgar rivers combine. Like the Kabul, the Lowgar rises in the mountains separating the Helmand and Kabul drainages and flows easterly. The river is used to water the large fertile tracts south and west of the capital.

About 10 miles east of Kabul, the Kabul River cuts through the mountains along the eastern rim of the Kabul Plain flowing through the Kabul River Gorge and into the reservoir above Sarowbi Dam. The Panjsher River flows into the Kabul at this location after flowing southwesterly from its headwaters in the Hindu Kush along the southern borders of Badakhshan and Takhar provinces. The Panjsher provides irrigation water for several settlements in places where the valley widens slightly.

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[10] *Afghanistan: The Eastern Provinces*, The Orkand Corporation, 1988.

The Ghowr Band River, a major tributary of the Panjsher, drains the Parwan province. The wider Ghowr Band Valley provides for considerably more agricultural activity.

East of Sarowbi, the Kabul enters a lower gorge before emerging onto the plains of the Jalalabad valley. The Laghman River, rising on the southern slopes of the Hindu Kush, flows into the Kabul just upstream of the second Kabul River dam, which provides water and power to Jalalabad. Southeast of the dam, the river is joined by the Sorkh Rud before passing through Jalalabad. Once past Jalalabad, the river picks up its last major tributary, the Kunar, before exiting the country.

The Jalalabad region is one of the major agricultural regions of Afghanistan. The lower reaches of all the major and minor tributaries and the broad band of land on either side of the city were all irrigated and productive regions before the war.

Groundwater is used on approximately 21 percent of the total area irrigated in the region (59,700 ha. of 284,600 total ha.). Highest usage is primarily in the drier western provinces such as Wardak, Parwan, and Kabul, where groundwater irrigates 42, 24, and 33 percent, respectively, of the total land area irrigated in each province.

Most of the rainfall in the eastern region falls in the winter and early spring. As with the southeastern region, a shorter period of rainfall occurs occasionally in the late fall when the southwest monsoon extends west of the Indus, affecting the margins of eastern Afghanistan.

Self-Contained System
(One Drainage Region)

Central Region
(Self-contained System)

The Central Drainage Region corresponds roughly to the area of the province of Ghazni. The Ghazni River drains this region, flowing ultimately to Lake Ab-e-Istada, a lake with no outlet. The region is thus a closed drainage basin supplying water to none of the other regions. The part of the Ghazni River contained within this region drains about 5,400 km^2 or about 1 percent of the country as a whole. The basin generates only 313 million m^3 per year, accounting for less than 1 percent of the total annual runoff in Afghanistan.

Groundwater usage is high in the Ghazni region with 27 percent of irrigated land supplied by underground water.

Almost all agricultural land is in the country's river valleys, near flowing water. River-valley water-table levels are, in general, closely related to streamflows. Streamflow data provide a reasonably clear picture of the water supply affecting river valley crop agriculture, even where irrigation water is drawn from wells and *karezes* rather than directly from the rivers themselves. In any given year, the amount of irrigated land is almost twice that of rainfed land. Irrigated land is more productive than rainfed land. In the case of wheat, the irrigated crop accounts for between four and five times the production of rainfed land.

Levels of precipitation vary substantially from year to year in Afghanistan. Deforestation has reduced the usefulness of this supply because much of the water rushes down streams in torrents instead of being retained along the way. However, Afghanistan's streams have always experienced torrential and highly variable flows. Other factors are responsible for difficulties in capturing Afghanistan's surface waters for use in agriculture, but weather patterns and steep gradients are the root causes.

Man-made irrigation systems are used to capture water for agriculture in all inhabited regions of Afghanistan. Canal systems predominate in the North. In regions south of the Hindu Kush, canals are also utilized, but significant use also is made of *juis*, simple diversion channels from small streams and rivers, and of *karezes*, hand-dug subterranean channels that direct water from permanent water tables under mountains or hills to the surfaces adjacent to villages or their fields. Relatively large irrigation projects are located in the Helmand and Nangarhar valleys, and in regions close to Herat and Konduz. Urban water and sanitation systems are provided only in parts of Kabul and some of the larger cities.

At least half of the water captured for agricultural use by Afghanistan's irrigation structures and systems is wasted. Reasons include inefficient irrigation technology, lack of system maintenance, war-related destruction of irrigation structures, and overwatering. Overwatering raises the water table, brings salts to the surface, and severely damages the agricultural potential of the land. Even where water is under control or could readily be brought under control by using existing technology, farmers may not make the investment in crops required to use this water productively because they do not know in advance that water will be available when needed.

Because of experience with years of drought, most Afghan farmers are defensive when making decisions about areas to be planted and investment in agricultural inputs. It takes well-established farmers 2 or 3 years to recover from a single crop failure caused by drought. For others in less fortunate circumstances, crop failure can mean loss of land ownership and starvation for their families. In such circumstances, uncertainty concerning future water availability leads to conservative planting decisions.

Ghazni, at an elevation of approximately 2200 m, receives approximately 20 to 30 cm of rainfall each year. The higher elevations within the basin receive about 30 to 40 cm of rain annually.

Water Resources Infrastructure

Figure 2-8 provides an overview of water resources and irrigation systems in Afghanistan, showing regions irrigated by canals and by *karez* systems. Before the Soviet invasion, there were approximately 2,586,000 ha. of irrigated land in Afghanistan, supplied from canals (85 percent of the area), springs (7 percent), *karezes* (7 percent), and wells (less than 1 percent).

Most of the easily accessible fertile lands along the rivers have long since been irrigated by traditional means, such as construction of intakes using stone and brush to divert water into hand-dug, gravity-flow conveyance channels (*juis*). Intakes usually have command areas of less than 3000 ha.[11] Although many modern irrigation projects have been developed over the past 30 years, most surface water is still irrigated using traditional methods (about 90 percent).

Traditional irrigation has several drawbacks. The first is inability of intakes to bring enough water into the canals once river levels drop. Modern systems solve this problem by constructing a weir structure that raises the level of the river surface to a minimum elevation for diversion into improved canal structures. Second, both intakes and canals are frequently damaged by floods to the extent that they are not functional during the critical part of the growing season. Repair groups must be formed, materials obtained, and repairs undertaken—all requiring time, which is precious during the growing season. Third, traditional canal systems are often physically inadequate for efficient distribution of water. Canal sections are under- or over-sized, irregularly shaped, and poorly located. In addition, poor irrigation practices (over-irrigation in the upstream end resulting in water shortages in the downstream end) and an inefficient water rights system add to the problems of inadequate water delivery. The consequences of war damage and lack of regular maintenance have resulted in further significant reductions in efficiency.

As mentioned previously, many of the modern systems include weir and diversion structures that increase the season over which water can be diverted by raising the level of the river. However, these systems are limited by the amount of water flowing in the river. During the low-flow season,

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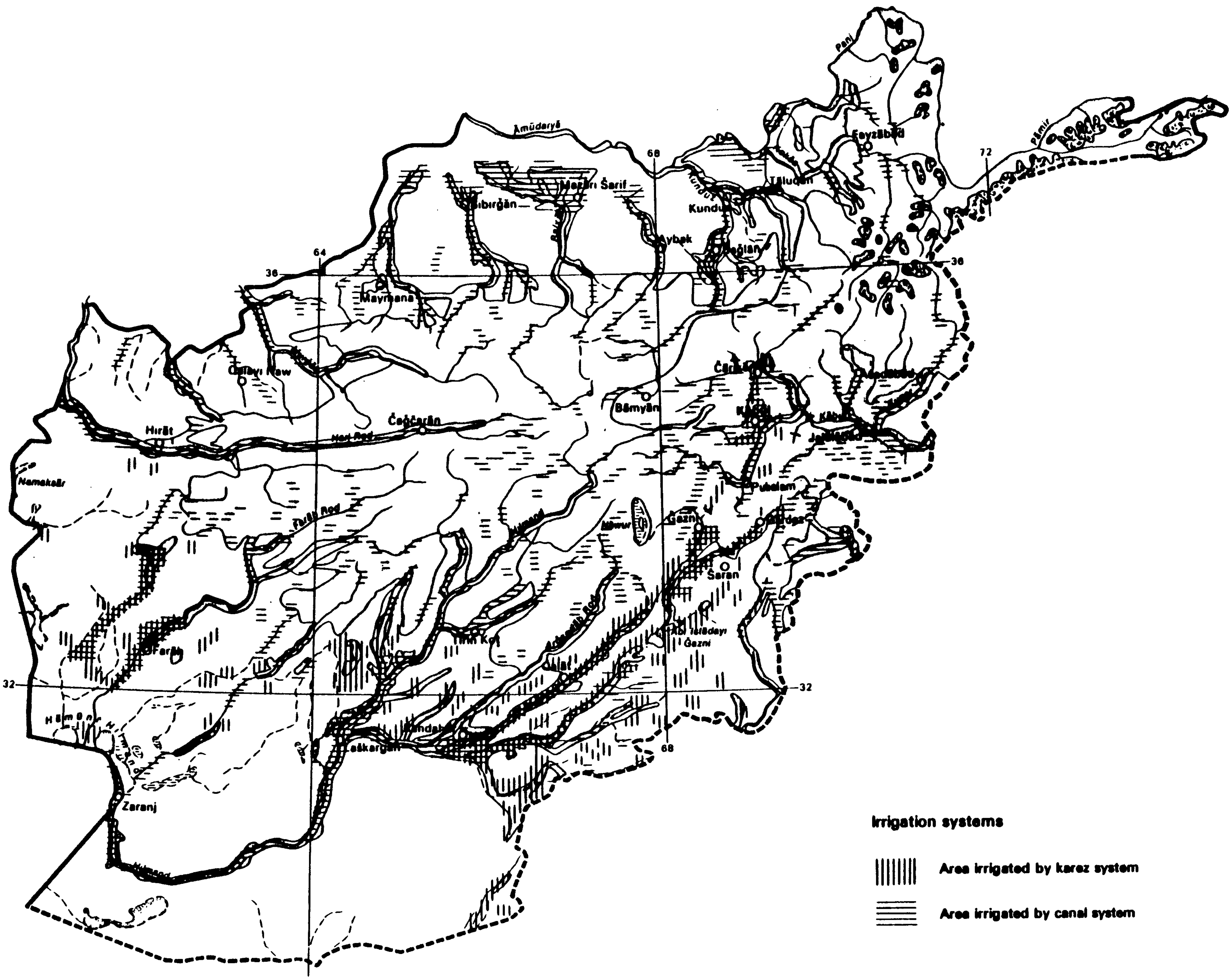
[11] Aziel, M. *Economic Analysis of Water Resources Projects in Developing Countries: A Case Study of the Helmand-Arghandab Valley Projects in Afghanistan*, 1964, page 366.

Figure 2-8. Irrigation Systems



Source: National Atlas of the Democratic Republic of Afghanistan. Warsaw: GEOKART, 1985.

crop-water demands can still exceed available supply. The construction of storage dams has been undertaken in several provinces to overcome this limitation. Reservoirs store the river flow that would normally be lost during the high runoff season when crop demands are low. This water is released later in the season in anticipation of increasing crop demands. Existing water development projects are described in Chapter 3. Dams have been constructed for both conservation and power production but are relatively rare because of the high investment required.

A significant amount of irrigation is accomplished using underground water, particularly in the Ghazni, Zabul, Farah, Helmand, Kandahar, Oruzgan, and Kabul provinces.[12] Aziel describes *karez* development as follows:

> The *karez* method of irrigation is particularly adaptable at the foot of mountains or high plateaus surrounded by hills. The area where water is to be used must preferably be at the foot of a substantial slope. The land must first be investigated to ascertain whether there are springs, whether moisture is present and whether moisture-absorbing plants and grasses seem to thrive. If so, a trial hole is dug. The depth of holes varies, usually from about 5 to 50 m, depending on the presence of water. If water is found, a succession of holes, about 30 to 100 m apart, are dug in the line of direction that the water seems to be flowing. The holes are then interconnected by a tunnel with varying height and width. This system is then extended, sometimes up to distance of 50 km, or until the gradient of the tunnel reaches the earth's surface and where, presumably, the command area is to be irrigated. Whenever a larger quantity of water is desired, new *karez* systems are integrated with an existing system or constructed independently.

Karez yields range from less than one liter per second to more than 200 liters per second and, like surface water, vary with the season. A major disadvantage of the *karez* system is that the discharge occurs throughout the year, wasting flows that occur during the winter. Underground water quality is also usually poorer (saltier) than surface water.

Numerous wells have also been dug in the past two decades, primarily as a result of the severe droughts that have occurred during the period but also because of the availability of pumps and diesel fuel.

Water Consumption Patterns

Table 2-6 presents rough estimates of total annual water consumption in Afghanistan by humans, animals, business and government establishments, and agriculture, who consume approximately 31 billion m^3 of water annually. Irrigated agriculture uses the largest percentage among the four, representing almost 89 percent of the total water consumption.

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[12]Aziel, M. *Economic Analysis of Water Resources Projects,* 1964, page 366.

Table 2-6. Rough Estimates of Water Consumption in Afghanistan

	Base	Projection Quantity	Consumption Factor Measure per day	Annual Factor	Annual Use (m^3)
Human					
Urban—Kabul	Pop 1	1,650,000	25 l	0.365	15,056,250
Urban—other	Pop 1	1,380,000	20 l	0.365	10,074,000
Rural—settled	Pop 1	9,040,000	15 l	0.365	49,494,000
Nomads	Pop 1	900,000	10 l	0.365	3,285,000
Subtotal	-	12,970,000	-	-	77,909,250
Animals					
Cattle	Head 2	2,160,000	25 l	0.365	19,710,000
Sheep and goats	Head 2	8,739,000	3 l	0.365	9,569,205
Other	Head 2	6,350,000	5 l	0.365	11,588,750
Subtotal	-	17,249,000	-	-	40,867,955
Government and Private Establishments					
Industry	GDP 3	15.114	4,500 m^3	260	17,683,380
Other	GDP 3	13.065	1,500 m^3	260	5,095,350
Subtotal		-	-	-	22,778,730
Agriculture					
Irrigated	ha. 4	2,125,000	43 m^3	300	27,412,5000,000
Rainfed	ha. 4	931,000	18 m^3	200	3,351,600,000
Subtotal	-	3,056,000	-	-	30,764,100,000
Total	-	-	-	-	30,905,655,935

Notes: Consumption and annual factors are derived from Nathan-Berger estimates. When consumption factor is measured in liters, the annual number is divided by 1000 to yield annual use in cubic meters. GDP = gross domestic product, ha. = hectares, l = liters. GDP is measured in billions of Af.
Sources: Projection quantities for Pop 1 are from Macroeconomic Database Development, Volume I, p. 23, Table 3-1 (1990-1991 estimate); for Head 2 from Macroeconomic Database Development, Volume II, Table A 11-13 (1990-1991 estimate); for GDP 3 from Macroeconomic Database Development, Volume I, Table 3-2 (1990-1991 estimate); for Hectares 4 from Afghanistan Land Ownership Study, p. 14, Table 1 (1989-1990 estimate).

Water consumption estimates, together with other estimates in this report, represent a start toward compiling a comprehensive account of the sources and uses of water in Afghanistan. Nevertheless, caution should be exercised when comparing source estimates (e.g., 236 billion m^3 annual precipitation on Afghanistan's land area, 65 billion m^3 streamflow) with the consumption estimates in Table 2-6.

First, the "consumption" categories presented in Table 2-6 do not purport to include the disposition of all the precipitation that falls on the surface of Afghanistan in a given year. In particular, they exclude precipitation that falls on pasture land and forest land. These two land categories

probably receive approximately 73 billion m^3 and 8 billion m^3, respectively, of Afghanistan's average annual precipitation. Second, water is often used and reused for irrigation as it descends from higher to lower altitudes in Afghanistan. Because repeated uses take place, conclusions concerning efficiency in the use of irrigation water cannot be drawn from direct comparisons between data on overall sources and uses. Finally, consumption factors used in the table represent very gross estimates. They are partly based on data for Afghanistan and partly on data from other dry developing countries. Given data availability, most of the consumption estimates require more guesswork than do estimates of annual precipitation and streamflows. Nevertheless, the consumption data do contribute a quantitative perspective and help to provide a background for general conclusions concerning the adequacy of Afghanistan's annual endowment of water and the efficiency with which that endowment is used.

Chapter 3

WATER DEVELOPMENT PROJECTS AND STRATEGIES

This chapter summarizes water development projects and strategies, including those in irrigation, hydroelectric power, and drinking water supply, that were undertaken before Soviet intervention in Afghanistan.

Irrigation

Afghanistan has a rugged topography; land suitable for cultivation constitutes only 12 percent of the total surface area. Because of Afghanistan's aridity, agriculture depends almost entirely on irrigation. Before the war less than 4 million ha.—nearly 2.6 million irrigated and 1.3 million rainfed—were being cultivated. However, much of the irrigated area received inadequate water supply. The source of irrigation water are shown in the following table:

Source	*Number*	*Area Cultivated (million ha.)*	*Percentage of Total*
Canals	7,822	2.210	85.0
Springs	5,558	0.190	7.3
Karezes	6,741	0.170	6.6
Wells	8,595	0.020	1.1
Total		2.590	100.0
Traditional irrigation		2.400	92.7
Modern irrigation		0.190	7.3

Apart from the construction of a few large irrigation projects in recent years, most of the irrigated land has been irrigated by traditional systems developed with hand tools by farmers. Groundwater traditionally has been diverted for irrigation through *karezes* and wells. Pumping from wells is a relatively new development.

The flow of water into canals is ample in the spring, but for a significant part of the land that is irrigated during any given year, irrigation

water is in short supply before the irrigation season ends. It has been estimated that up to 30 percent of the irrigated area remains without water during the growing season because of shortages caused by siltation of canals, destruction of diversions, and uneven distribution of irrigation water. The land tenure system, fragmentation of land, and traditional water rights further constrain improved irrigation and rational water distribution. The overriding constraint has been lack of a consistent strategy for resource development.

Over the last 40 years, expansion of the area under irrigation through large capital-intensive projects dominated government policies for irrigation development. However, during this period the government developed less than 90,000 ha. of irrigated land equipped with modern facilities. Because of limited implementation capacity, poor project planning, and other reasons, a number of large-scale projects remain incomplete and nonoperational.

Throughout this period, rehabilitation and modernization of existing irrigation facilities, on which 90 percent of Afghan agriculture depends, received little attention. Most of the funds in agriculture and irrigation have been spent on a few large-scale projects, which donors supported because of their high visibility. In most cases, however, the benefits from heavy investment in large-scale irrigation projects, such as increased production and income, have been disappointing. The projects are described in the following subsections.

Helmand-Arghandab Project

The objective of the Helmand-Arghandab project was to irrigate new areas in the southern Helmand and Arghandab region, develop organized settlements, and increase agricultural production for both domestic use and exports. Formal development of the project began in 1945, in association with Morrison Knudsen, an American engineering firm.

The initial estimated cost of the project was $63.7 million, including $53.7 million in foreign exchange. By 1949, the government had spent $20 million in Afghan resources on the project. To complete the basic irrigation work, the government requested from the U.S. Export-Import Bank a loan of $21 million, which was approved in 1949. By 1953, the following irrigation facilities had been constructed.

- Kajakai Dam on Helmand River (91.5 m high by 270 m long, 1.7 billion-m^3 capacity)

- Arghandab Dam on Arghandab River (44 m high by 530 m long, 479 million-m^3 storage capacity)

- Boghra diversion dam and canal (74 km long, carrying 75 m^3 of water per second and supplying water to the regions now known as Marja (18,000 ha.) and Nadi Ali (14,000 ha.)

In order to build these facilities ahead of schedule, the implementing agency dropped smaller projects, as well as essential surveys that later impeded the progress of the project. While the main irrigation infrastructure was in place, drainage, land development, and water distribution networks were still required throughout the project region. The Export-Import Bank provided a second loan for $18.5 million for drains, land development, and power in the Helmand-Arghandab valley. Meanwhile, an agreement with the U.S. International Cooperation Administration was signed for the first time. Construction of Darweshan diversion dam and some large canals to irrigate the Darweshan and Shamalan and in Kandahar were completed between 1953 and 1960.

By 1955 Afghanistan had spent about $70 million of its scarce resources on the Helmand-Arghandab project, but the return from it, in increased production and income, was low because of both human and technical problems that plagued the project from the start. Improper drainage was a major problem throughout the valley. Because the main canal was too low, the natural gravity drainage was hampered and fields tended to be overwatered. As a result, salinity increased severely, destroying the soil. Salinity, as well as waterlogging, also resulted because the fields were not flat and the lower regions received much more water than they needed.

Even in the mid-1960s many fields were still suffering from waterlogging, and production fell by more than 50 percent. The settlement of inexperienced farmers in the project caused another serious problem. Newly irrigated land was distributed to nomads of different ethnic groups without adequate support services and preparation. Moreover, the technical and financial bases for maintaining about 5,000 km of irrigation canals, drains, and roads were also inadequate.

Administrative procedures and lack of coordination among decision makers in Kabul and Helmand, and similarly in the United States, resulted in a waste of time and resources. Although some of the basic problems remained, signs of genuine improvement appeared toward the late 1960s. During this period and in subsequent years government programs emphasized construction of drains and irrigation networks instead of large irrigation facilities.

From 1945 to 1975 Afghanistan invested about $130 million in the Helmand-Arghandab project, of which the United States contributed $80 million in loans and grants. Expenditures on the Kajakai hydropower project, which will be discussed later, has not been included in this discussion.

Although it took longer than expected, the Helmand-Arghandab project began to contribute significantly to the Afghan economy by the mid-1970s. Land under cultivation increased from 77,000 to about 145,000 ha. About 7,400 families were settled in newly irrigated regions. Average farm incomes increased by as much as tenfold. Wheat production increase from 32,000 tons in 1966 to about 110,000 tons in 1975. Cotton was introduced to the region, and production reached 23,000 tons in 1975.

However, the lack of balance between irrigation capacity and drainage system necessary for intensive farming has continued to hamper effective cultivation and profitability. A drainage and maintenance project was prepared in 1976 with the assistance of A.I.D. The project was aimed at providing a network of main drains and farm drains covering 30,000 to 40,000 ha. of existing land. A.I.D. was expected to provide up to $20 million over 7 years.

Drainage work was started in four priority regions (Marja, Nadi Ali, Shamalan, and Darweshan) using labor-intensive techniques. From 1976 until the Soviet invasion in late 1979, considerable progress had been made in implementing the project. During this period Afghanistan spent about $12 million on the drainage project, of which A.I.D. contributed $8 million in grants. However, A.I.D.'s assistance was suspended in 1980 because of security conditions. Thus, a drainage system for more efficient cultivation awaits completion.

Nangarhar Irrigation Project

The objective of the Nangarhar irrigation project was to introduce large-scale mechanized state farming, produce new agricultural products such as citrus and olives for exports, and improve the socioeconomic conditions of a region with inadequate cultivated land. The Nangarhar project began in early in 1960 with financial and technical assistance from the Soviet Union. By 1945 the following facilities were in place.

- Darunta dam on Kabul River, near Jalalabad (41 million-m^3 capacity)
- Darunta main canal (70 km long, carrying 50 m^3 of water per second)
- A pumping station (capacity of 4 m^3 of water per second, 22-m lift)
- A hydropower station (11.5-MW capacity)

At the beginning of the project, the total cost was estimated at $35 million, including $22.4 million in foreign exchange. In subsequent years, however, the cost mushroomed beyond that expected because of cost

overruns caused by changes in the project objectives and inaccurate cost estimates. The total cost of land leveling and preparation was completely underestimated.

In irrigation infrastructure, power, drains, and land preparation and cultivation, Afghanistan by 1977 had spent about $143 million, of which the Soviet Union financed $62 million in loans.

During implementation, a number of problems were encountered. Because of poor soils, topsoil had to be transported to many regions at great expense. The dam site at Darunta, selected by Soviet experts, had unstable strata and thus had to be grouted at tremendous cost. The rising water table, particularly in the regions previously irrigated by the farmers, indicated that other problems would develop. Maintenance of large irrigation facilities also appeared to be a serious problem.

The total area of the project is 31,200 ha., of which farmers had previously irrigated 6,700 ha. From the beginning of the land development program in 1964 to the end of 1976, a period for which information is available, some 15,800 ha. of new land was developed. The Hadda and Ghaziabad state farms, which constitute a total area of 5,800 ha., were developed in the late 1960s. In the mid-1970s work was still in progress on two newly constructed farms covering a total area of about 2,500 ha. The remaining 7,500 ha. was distributed to landless farmers in Nangarhar under the government settlement program. Much of the land distributed was considered unsuitable for settlement; thus, large numbers of settlers left the region even before the hostilities began.

The Nangarhar project appears to be economically unfavorable, despite the large investment made in it for decades before the war. During 1978-1979 production on government farms was reported to be as follows:

Product	*Tons*
Wheat	1,683
Other cereals	332
Citrus	6,500
Olives	1,319
Milk	760

The total gross value of production in the project area, at 1978 prices, was Af. 240 million ($5.6 million). The contribution of the project to foreign exchange earnings was also limited. Export earnings from sale of citrus and olive to the Soviet Union in 1978 was less than $0.7 million.

Parwan Irrigation Project

The Parwan irrigation project is located north of Kabul in Parwan. Construction started in 1947 with assistance from the People's Republic of

The Nathan-Berger team divided Afghanistan into nine drainage basins for this analysis. The boundaries of these regions, originally established by plotting individual watersheds, have been adjusted to reflect provincial boundaries. While the adjustments to provincial boundaries to some extent violate topographic imperatives, these modifications permit comparisons of weather data and surface-water flows with data on agricultural production. The Geographic Information System (GIS) system being developed by Development Alternatives Inc. (DAI) and Earthsat may present information on rainfall, snow accumulation, and agricultural production by drainage regions whose boundaries are determined solely on the basis of topography (without the adjustments to provincial boundaries used in this report). However, satellite information available on agriculture from DAI/Earthsat when the study was conducted was limited to a relatively small group of regions of Afghanistan near the Pakistan border. Nathan-Berger therefore created "provincialized" drainage basin boundaries in order to make rough comparisons of the available data nationwide. When GIS coverage is extended to the entire country, a more refined analysis may be possible. A summary of the drainage regions, their relationships with the major river systems that they are part of, and the provinces they include follows.

Drainage Region	*Major River System*	*Provinces*
Western	Helmand Arghandab	Farah
Southwestern	Helmand Arghandab	Nimroz
Southern	Helmand Arghandab	Helmand, Qandahar, Oruzgan, Zabul
Central	Self-contained	Ghazni
Southeastern	Indus	Paktya, Paktyka
Eastern	Indus	Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar
Northeastern	Amu Darya	Badakshan, Bamian, Baghlan, Konduz, Takhar
Northern	Amu Darya	Samangan, Balkh, Jowzjan, Faryab
Northwestern	Hari Rud	Badghis, Herat, Ghor

To be useful for agriculture, water must be delivered to the root systems of crops during key periods of growth. The time-phased water needs of the crops grown in particular regions constitute "agricultural demand" for water in these regions. The supply and agricultural demand for irrigation water in each of the nine drainage regions were estimated by the Nathan-Berger team. Regions most likely to be affected by water constraints were identified on the basis of prewar and current conditions.

China. The objective of the project was to irrigate 24,800 ha., including 15,300 ha. already inadequately irrigated. The project has the following components:

- A 56-m-long by 9.2-m-high diversion dam on Panjsher River near Gulbahar (1,200 m^3-per-second capacity)

- A main canal 24.3 km long, carrying 29 m^3 of water per second; a southern branch 21 km long, carrying 9 m^3 of water per second; and an eastern branch 18 km long, carrying 16 m^3 of water per second

- A hydropower plant on the eastern canal, with a capacity of 2,400 kW

- The Salang and Ghorband siphons, with capacities of 25 m^3 and 27 m^3 of water per second, respectively

- A pumping station on the southern canal, pumping 3.2 m^3 of water per second at a height of 20 m

The Parwan project was expected to be completed in the early 1970s, but a number of constraints, including weak project preparation, lack of skilled personnel, and institutional weaknesses, delayed completion by more than 5 years. Maintenance of irrigation systems was also a serious problem. Construction and expansion of irrigation facilities on private lands involved legal problems that hampered speedy implementation of those activities.

The major components of the Parwan project were completed in 1978; the remaining work was mostly agricultural development. From the beginning of the project to the end of 1977, $27 million, including $11.3 million in foreign exchange, was invested in the project.

Sardeh Irrigation Project

Work on the Sardeh irrigation project, located near Ghazni, started in 1942 with the assistance of the Soviet Union. The project has potential for irrigating about 12,000 ha. of new land in addition to improving water supplies on 1,100 ha. of existing land. The major components are as follows.

- A reservoir with a usable capacity of 164 million m^3

- A 900-m main canal, carrying 15 m^3 of water per second with two branches: the left fork canal (30.5 km long, carrying 8 m^3 of water per second) and the right fork canal (carrying 7 m^3 of water per second)

- A total of 452 km of secondary and tertiary canals

- A total of 451 km of drainage system and 216 km of roads

Although Sardeh reservoir was completed in the mid-1960s, construction of the related irrigation system was delayed considerably because of weak project planning and lack of equipment for construction and land leveling.

The project was completed in late 1977 at a total cost of $27 million, including $10 million in foreign exchange. Although the major components of the project were completed, full production did not start because of slow development of the distribution network and drainage system. Lack of maintenance of irrigation facilities was also a constraint. In 1977 less than 200 ha. of new land were cultivated.

First Khanabad Irrigation Project

The Khanabad irrigation project region covers part of the Khanabad valley, where irrigation has been practiced during the last 100 years. However, as in many other traditional irrigation systems in the country, the irrigated area suffered from lack of water control and consequent water shortages in certain subareas. The objective of the project was to provide adequate water for 26,600 net ha. of existing land.

The project, approved by the World Bank in mid-1971, became effective at the end of 1972 because of delays in government ratification. Selection of consultants and organizational problems further delayed implementation. Substantial cost increases and changes in project design resulted in reappraisal in 1975, resulting in approval of a supplementary World Bank credit.

Project construction started in 1976 and represented the first phase of a program for modernization of irrigation systems in the Khanabad valley. By 1979 about 80 percent of the project had been completed. World Bank assistance was suspended in 1979 because of security conditions. The main components of the project are as follows.

- A diversion weir on Khanabad River (161.5 m long by 6.7 m high)
- A right bank canal (8.3 km long, carrying 12 m^3 of water per second)
- A left bank canal (17.8 km long, carrying 70 m^3 of water per second)
- Other irrigation structures, including intake regulators

According to the project document, incremental production was to consist of cotton (10,568 tons), wheat (3,218 tons), and rice (1,282 tons). The

gross value of incremental agricultural production at 1977 constant prices was estimated at $4 million annually. There was provision of an 18-m fall for generation of 16.5 MW of hydropower. Construction was awarded to the Helmand Construction Unit, a government contracting corporation.

The total cost of the project was estimated at $20 million, including $11.6 million in foreign exchange. The World Bank credit of $15 million financed 75 percent of the project.

Second Khanabad Irrigation Project

In late 1977 the government of Afghanistan requested World Bank assistance in implementing the second phase of the Khanabad irrigation project. The proposed project, a continuation of the first Khanabad irrigation project, included the following activities.

- Construction of water control and drop structures on the existing canals, serving 26,600 ha. under the first phase of the project
- Remodeling of existing irrigation and drainage systems on 13,660 ha. to the west of the first project (construction of a new irrigation system to serve 1,200 ha. of rainfed land)
- Provision of agricultural extension services and credit to farmers on 41,460 ha.
- A feasibility study for a storage dam on Khanabad River
- A program to control malaria in the project region, covering 200,000 inhabitants

The total cost of the project was estimated at $28.7 million, of which $16.1 million would be foreign exchange. The World Bank credit of $22 million approved in February 1978 was expected to finance 77 percent of the total cost.

It was estimated that at full development in 1987, the incremental production of major agricultural crops would involve 11,750 tons of rice, 8,700 tons of wheat, and 17,900 tons of cotton. The total gross value of incremental production would have been $9.5 million.

Although the project was approved by the World Bank in early 1978, it was not implemented because of security conditions.

Hari Rud Irrigation Project

The Hari Rud Valley has more than 73,000 ha. of potentially irrigable land. However, because of water shortages only 40,000 ha. are irrigated annually, of which only 30 percent receives adequate water during the critical months June, July, and August.

The average annual flow of water in Marwa, above Hari Rud, is estimated at 2 billion m^3 per year, but because of a lack of modern water control facilities, much of this water is wasted during the flood season. As a result, agricultural and livestock production is constrained by the limited supply of traditional diversion works.

The objective of the Hari Rud irrigation project, undertaken in 1975, was to improve utilization of floodwater and provide the required facilities to execute an effective program of irrigation on 40,000 ha. of existing land.

A UN special fund study in 1969 emphasized the need for effective storage of some 300 million m^3 of water that could be stored at either Salma or Assarassam, upstream of Hari Rud River. In 1974 an Indian engineering team studied the Salma site and recommended construction of a stone masonry gravity dam.

The Hari Rud irrigation project includes the following components.

- Construction of a 104-m-high dam at Salma, with a storage capacity of 650 million m^3, of which 545 million m^3 would be usable

- Construction of a hydropower station with a firm capacity of 10,000 kW and a seasonal capacity of up to 30,000 kW

- Construction of a diversion dam and intakes of major existing canals

- Construction of 30 km of secondary roads and a 200-m bridge across the river

It was hoped that once the project was completed, irrigation conditions would improve for the entire 40,000 ha. in the main valley. An improved water supply would considerably improve production of wheat, cotton, sugar beet, fruits, and livestock. The diversion tunnel was completed, a construction plant was erected, and 300,000 m^3 of rock was excavated for the spillway before the project was stopped.

The total cost of the project was estimated at $57 million, including $40 million in foreign exchange. Saudi Arabia granted a loan of $55 million for

construction on highly concessional terms. By 1979, more than $20 million was spent on procurement of equipment and civil works.

Gawargan and Chardarah Irrigation Projects

The Gawargan and Chardarah irrigation projects are located in Konduz and Baǧhlan, which have considerable potential for agricultural development. Both projects involved existing irrigated regions with traditional diversion structures that have experienced periodic flooding. Waterlogging has been a serious problem limiting increase agricultural production.

The projects were supported by the Asian Development Bank and were intended to use waters from Konduz River for pump irrigation of 3,400 ha. of new land and improvement of traditional irrigation over 24,900 ha. of existing area. The projects included the following components.

- Construction of a diversion weir and remodeling of Gawargan, Darqad, Jul-nau, and Larkhawi canals, carrying 14.5 m^3/second of water for irrigation of 10,300 ha.

- Construction of a pumping station (3.8-m^3/second capacity, 25-m lift)

- A small hydropower station (1,500 kW capacity) on Ajmeer canal, Pul-i-Khumri, supplying electricity to the Larkhawi pumping station

- Construction of a permanent diversion weir (26 m^3-per-second capacity) to irrigate 18,000 ha. and remodeling of related canals

- Improvement of irrigation network roads and drainage facilities

Once the project completed, adequate water supply would be available to the project region, and water losses and waterlogging would be reduced to a minimum. The total cost of the project was estimated at $25 million, including $16.9 million in foreign exchange. According to official documents, about 70 percent of the project was completed by 1978. Assistance from the Asian Development Bank was suspended at the end of 1978.

Kajakai Spillway Gates

The Kajakai spillway gates project comprises construction of eight regulating steel gates on the existing Kajakai dam, which will increase its capacity from 1.7 billion m^3 to 2.7 billion m^3 by raising the height of the dam by about 2 m. The project started in 1976 with assistance from the Asian Development Bank that was suspended in 1979 because of security conditions. A part of the civil works was completed, and gates arrived at the project

site. Completion of this project would provide systematic irrigation for an additional 26,000 ha. of land in upper Helmand, where water is in short supply. The total cost of the project was estimated at $18 million, including $14 million in foreign exchange. Implementation would increase the value of the Kajakai dam as a flood control facility.

Hydroelectric Power

Before the Soviet invasion, electric generating capacity was estimated at 360 MW, comprising 255 MW of hydropower, 80 MW of steam-type gas, and 25 MW of diesel. Electricity supply was available only in some urban regions. About 6 percent of the Afghanistan's population had access to electricity. The rural and urban poor populations had little or no access to electricity. Today, because of the war, the situation is worse.

Construction of the first hydropower plant, with a capacity of 1,500 kW, began before World War I by an American engineer in Jabul-u-Seraj (Parwan). However, because of technical problems and complete lack of Afghan technical personnel, it took Afghanistan 12 years to complete the project.

Before World War II, German engineers commissioned a number of small hydropower projects around Kabul and several other provinces. Except for a few, these projects were unsuccessful. Almost all the major hydropower projects were constructed with outside assistance between 1956 and 1976. The following table summarizes the projects.

Location	*Installed (MW)*	*Completion Date*
Sorobi	22.0	1956
Naghlu	100.0	1966
Mahipar	66.0	1967
Kajakai	33.0	1976
Darunta	11.5	1963
Pul-i-Khumri	9.5	
Chak-i-Wardak	3.3	1920
Subtotal	245.3	
Others	9.4	
Total	254.7	

It is reported that operating conditions of these facilities have markedly deteriorated over the past 13 years because of lack of maintenance. Moreover, during the same period, no new hydropower project has been built.

As can be seen from the preceding figures, about 78 percent of electricity-generating capacity has been concentrated in Kabul. However, operation of these plants depends greatly on the flow of water, which is subject to seasonal variations. As a result, the system in Kabul suffers from

supply shortages in a dry year. The power deficit in Kabul currently is estimated at 250 million kWh.

Electricity from hydropower sources has been heavily subsidized. The electricity tariff remained unchanged for nearly two decades before the war until it was increased 30 percent in early 1977. Before establishment of the Ministry of Water and Power in 1976, the activities of the water and power subsectors were completely uncoordinated. The major hydropower project executed before the war are described in the following subsections.

Naghlu Hydropower Project

The Naghlu hydropower project is located 70 km east of Kabul. The largest hydropower station in Afghanistan, it was completed in 1966 with financial and technical assistance from the Soviet Union. The original capacity of the Naghlu project was 67 kW, but installing a fourth turbine and raising the Naghlu dam 1 m in the early 1970s increased the capacity of the plant to 100 MW. A 54-km transmission line connects the plant with a substation built in the eastern part of Kabul city. Total expenditure amounted to $60 million, including $29 million in foreign exchange.

Kajakai Hydropower Project

Before 1976 the only source of energy in the Helmand Valley was the Boghra hydropower station, which has a capacity of 2.4 MW. During winter, when the demand for power was high, part of the Boghra plant became idle because of insufficient water in the canal. At the same time, Kandahar city, where demand for electricity was growing rapidly, was powered by some worn-out diesel generators.

To meet the growing demand electricity in the region, the government of Afghanistan planned to implement the Kajakai project in 1968.

The plant, completed in 1977 with an installed capacity of 33 MW with available space for a third unit of about 18 MW, cost $35 million. Of this amount, $25 million was financed by A.I.D. and $10 million was financed through the government budget.

A 110-kW transmission line 221 km long, connecting the power station with Kandahar and Lashkargah substations, also was completed in 1977. However, the line was destroyed early in the war; as a result, the Kajakai hydropower plant has been unused since 1978.

Darunta Hydropower Project

The Darunta hydropower project, which has a capacity of 11.5 MW, was built at Darunta dam near Jalalabad city in 1963 with assistance from the

Soviet Union. It is an important component of the Nangarhar irrigation project. Before the war it produced about 31.8 million kWh of electricity per year. According to official sources, more than 56 percent of the electricity was used to operate water pumps on the Hadda state farm and other establishments. The cost of this project cannot be determined now because the project is included in the overall cost of the Nangarhar irrigation project. However, unofficial sources report that the cost of the Darunta project at 1963 prices would not exceed $3 million, including $2.4 million in foreign exchange.

Mahipar Hydropower Project

Located about 40 km east of Kabul, the Mahipar hydropower project was completed in 1967 with assistance from the West Germany. It has three turbines with a total capacity of 66 MW. Even though two barriers against sand were constructed, the turbines require repair periodically to correct damage from sand drops. The project cost $27 million, of which $25 million was in foreign exchange.

Sorobi Hydropower Plant

The technical study and design of this project were carried out by German experts toward the end of the 1930s. However, construction of the project was delayed by World War II. After the war, Afghan authorities resumed work on the project assisted by German experts. The project, which has a capacity of 22,000 kW, was completed in the early 1950s.

According to recent reports, water at the Sorobi diversion dam is passing across the falls without generating power. The Kabul government proposed to construct a new power station downstream of the dam with an installed capacity of 80 MW but never started construction of it.

Small-Scale Hydropower Projects

During the 1970s the government of Afghanistan implemented three small-scale projects in remote regions:

- A plant, completed in 1974, built in Ghorband (Parwan) with assistance from Indian experts (600-kW capacity)
- A small hydropower plant on Pech River in Asadabad (Kunar), started in 1976 with assistance from UNDP and completed in 1978 but not used because of the war (700-kW capacity)
- A three-turbine (each with 250-kW capacity) power plant started on the Bamian River with Indian assistance but not completed because of security conditions

The total cost of these projects was $3 million, of which $2.5 million was in foreign exchange.

Drinking Water Supply

Safe drinking water is very limited in both rural and urban regions in Afghanistan. About 1.2 million or 30 percent of the urban population have access to safe drinking water. About 70 percent of the urban water supply capacity is concentrated in Kabul. No reliable information on rural water supply is currently available. Before the war, however, about 400,000 villagers or 4 percent of the rural population were benefiting from safe drinking water.

Until recently the responsibility for planning and implementing water supply projects was divided between the Central Authority for Water Supply and Sewerage (CAWS) and the Environmental Health Department for the Ministry of Public Health (EHD). CAWS was responsible for supplying water to cities, whereas EHD was responsible for supplying water to rural regions. Major water supply projects implemented in recent years are described in the following subsections.

Kabul City Water Supply Projects

In Kabul, before 1975, when construction of modern water supply facilities began, piped water was available to a limited number of households. A survey conducted by CARE in 1972 of 1,572 households showed the following pattern of water sources:

	Number of Households	*Percentage of Total*
House connections	198	12.6
Public standpipes	472	30.0
Private wells	742	47.2
Public wells	120	7.6
River	34	2.2
Other sources	6	0.4
Total	1,572	100.0

A water master plan for Kabul was completed in 1974 with assistance from UNDP. The plan proposed development of the Kabul water supply between 1974 and 2004 in four phases. The first phase, launched in 1974, consisted of two major water supply projects: the Afshar project, financed by West Germany, and the Kabul water supply and sanitation project, financed by the World Bank.

The Afshar project, with a capacity of 15,000 m^3 of water per day, was completed in 1978. The project cost $8 million, of which $6 million was in foreign exchange. The World Bank project, with a capacity of 30,000 m^3 per

day, was completed in 1981 at a cost of $13 million, including $10.2 million in foreign exchange. This project included the laying of 200 km of distribution network and construction of two water reservoirs, each with a capacity of 5,000 m^3. To provide water to the city, 1,000 standpipes were installed.

When these projects were completed, total supply of piped water to Kabul increased from 15,000 m^3 per day in 1974 to 61,000 m^3 per day in 1983. The system installed served about 800,000 people, half the total population of Kabul. The other half drew water from private and public wells. The second phase of the master plan has not yet been started. Phase I, completed in 1982, and the older system make up the current Kabul water supply system.

Provincial Water Supply Projects

In early 1971, the town planning authority started a water supply project with assistance from the government of Japan to provide safe drinking water to four major cities: Kandahar, Herat, Mazar-i-sharif, and Jalalabad. The projects were completed in 1975. The overall system had a combined capacity of about 9,500 m^3 per day, which, on the basis of 60 liters per person per day, served about 160,000 people.

Between 1975 and 1979 these projects were expanded to benefit more people. New water supply projects were implemented in other towns. The capacity and coverage of these facilities are given in the following table:

	Capacity (m^3/day)	*Population Served*
Mazar-i-sharif	4,000	66,000
Herat	6,000	99,000
Kandahar	6,000	99,000
Jalalabad	3,000	50,000
Ghazni	3,000	50,000
Charikar	1,000	17,000
Kala-i-Nau	300	5,000
Khanabad	500	8,000
Total	23,800	394,000

Before the war, water supply facilities were also available in Lashkargah and Khost, but no information on these smaller systems is available.

Once these projects were implemented, total water supply in eight provincial towns increased from 9,500 m^3 per day to 23,800 m^3 per day, covering nearly 400,000 people. The cost of the program was $4.5 million, including $1.113 million in foreign exchange. During the 1980s the Kabul government could not implement sizable water supply projects outside Kabul because of security conditions.

The agricultural situation in Afghanistan has changed significantly in the decade since the war began. Irrigated area has declined by 21 percent between the years 1978-1979 and 1987-1988 with the largest declines reported in the region that includes Helmand, Kandahar, Nimroz, Uruzgan, Zabul, Ghazni, and Paktyka provinces. Because irrigated lands include such a large portion of the total cultivated land in these provinces—about 80 percent overall—the region has been particularly affected by damage to and destruction of both the modern and traditional irrigation systems. Significant numbers of people have been forced to flee.

On the basis of average water supply conditions and estimates of irrigated crop areas in the extensively developed southern agricultural region composed of Helmand, Kandahar, Zabul, and Uruzgan, the 1978-1979 water supply model showed surplus water available in the region. No water shortages were experienced in any month. Currently, primarily as a result of damage to the Helmand-Arghandab water distribution network, the amount of land irrigated has been significantly reduced (by about 107,000 ha.). However, the water supply is essentially unchanged. Rehabilitation of the existing distribution network appears to necessitate relatively minor repairs. Because surplus water is available, the southern region appears to offer one of the greater potentials for bringing large areas of previously irrigated land back into production.

Only one other region, the northeastern (Badakshan, Bamian, Baghlan, Konduz, Takhar), currently experiences water surpluses every month. Although the limited information available suggests that much of the prewar irrigated area of the region is currently used to produce crops, approximately 67,600 ha. of prewar irrigated land is estimated to be available.

Although the irrigated area has decreased in the remaining regions as a result of the war, none of these regions appear to offer short-term opportunities for expanding irrigated agriculture. Water shortages are still experienced in each of these regions at some point during the year. Shortages occur in the summer and fall in the southwestern (Nimroz), central (Ghazni), northwestern (Badghis, Herat, and Ghor), and northern (Samangan, Balkh, Jowzjan, and Faryab) regions. Shortages are experienced in the summer in the western (Farah), and eastern (Kabul, Lowgar, Wardak, Parwan, Kapisa, Laghman, Konar, and Nangarhar) regions. The regions experiencing the most severe shortages include the western (Nimroz) and central regions (Ghazni) where the ratio of supply to demand dips as low as 10 percent. The eastern region has the smallest shortages; the ratio of supply to demand is 90 percent in the lowest month.

Because a larger area was irrigated in these regions before the war, rehabilitation of agricultural lands to prewar levels will add further demands to the already overloaded water supply. To obtain optimum levels of production and expansion of crop areas, significant planning and investment

Rural Water Supply

Several studies identified contaminated water as a major source of illness in rural regions. Most of the rural population draw water from open canals that are polluted. From a 1976 survey by the Management of Sciences for Health of rural residents in three provinces, water supply sources are given in the following table:

	Percentage of Households Surveyed
Private wells	22.9
Village wells	1.6
River	5.9
Jui (open canal)	37.8
Spring	12.8
Karez	19.0

The rural water supply program in Afghanistan began in 1971. By 1977 the Ministry of Public Health, through the EHD, installed piped water systems in 55 large villages. Most of the systems were deep wells that fed the distribution network, which contained public standpipes. It was estimated that these systems have served about 100,000 people.

The EHD also installed about 800 hand pumps, which served 200 to 300 thousand beneficiaries. However, a sample survey showed that 50 percent of hand pumps and 60 percent of power pumps were nonoperational from lack of maintenance. Villagers had no responsibility for maintaining water supply facilities, and the overall management was centralized. From 1972 to 1976, for which information is available, about $2.5 million was spent on rural water supply facilities.

During recent years the Kabul government has been unable to implement water supply projects in rural regions systematically because of security conditions.

Problems in Implementation

Review of water development projects as a group indicates a number of institutional problems, such as excessive delays in approving projects, inadequate preparation of projects, limited capacity of implementing agencies, and underestimated costs.

Another fundamental problem has been the acute shortage of well-trained, experienced personnel in both the planning and executing agencies of the government. However, the effectiveness of existing personnel was greatly hampered by administrative deficiencies—centralization of decision making, lack of incentives, and delegation of authority—even in technical fields.

Extremely complicated domestic procurement procedures also impeded the speedy implementation of development projects.

The planning process has been uncoordinated, and projects were delayed because of poor project preparation. Besides poor preparation, development projects also suffered delays and cost overruns caused by delays in government ratification and inflation.

Delays in project implementation appeared to be extremely costly. A major part of foreign aid was allocated to water development projects, and slow implementation resulted in slow utilization of external resources.

Maintenance and operation of power projects, irrigation projects, and water supply facilities have always been major problems because of insufficient resources and skilled personnel. Inability to maintain investments led to a decrease in the benefits from the projects.

The government did not realistically and continually assess implementation constraints. The country faced a severe shortage of domestic resources. However, inconsistencies between investment requirements and available funds very often resulted in delays and substantial increase in investment cost.

Because of a deficient structure for project monitoring by government agencies, problems were not identified in order to enable the responsible authorities to act rapidly to remedy them. In the irrigation subsector, the full benefits of substantial investment in large irrigation facilities were often delayed because of slow development of the distribution and drainage systems. Delays in project implementation were also caused by traditional water rights and difficulties in determining land ownership because of the lack of cadastral surveys and outdated land registration.

Regionally, power requirements have been met haphazardly. This development pattern resulted from the limited financial and technical resources available in the country and the low level of economic development, as well as geographical and social factors. Implementation of an integrated program suffered from the absence of a coordinated approach and the lack of standardization in technology. Responsibility for the development of water resources was divided for many years and has changed frequently. This arrangement presented coordination problems and impeded smooth implementation.

In most cases, irrigation and power projects were handled by the donor; communication between the Afghans and the donors was inadequate at all levels.

In the water supply subsector, the primary constraint has been a lack of local resources. In addition, the implementing agencies have had limited

capacity in designing, and especially in constructing, water supply and sewerage works.

It was extremely difficult to implement, manage, and maintain the rural water supply projects through a central agency in Kabul. The participation of the local community in the design, implementation, and management of these systems was quite limited.

Chapter 4

WATER CONSTRAINTS ANALYSIS

The analysis in this chapter focuses on the resettlement of Afghanistan's internal and external refugees and the potential effects of water supplies on agricultural production. Relationships between control of water, agricultural production, and resettlement are discussed. A detailed quantitative analysis of the supply and agricultural demand for water is presented. Regions most likely to be affected by water constraints are identified on the basis of estimates of prewar and current conditions.

Water Control, Agricultural Production, and Resettlement

This section provides a conceptual overview of relationships among principal water constraints. The influence of water on Afghan life and settlements is discussed; a sociocultural perspective on irrigation technologies and water control systems is presented; effects of variations in snow and rainfall on agricultural production are examined; and resettlement constraints are addressed in terms of the human carrying capacity of the land.

Influence of Water on Afghan Life and Settlements

Control of water used for agriculture has long been considered an important factor in the ability of humans to create economic surpluses. The rise and decline of the world's early river valley civilizations have been substantially attributed to the technical competence and prudence with which humans applied water to the land.

Viewed in the aggregate and on the average, Afghanistan has a substantial basic endowment of annual precipitation and water flowing through its river systems. However, control of water and its timely delivery for agricultural uses remain central problems today. Some observers believe that farmers currently have less control over the country's water resources

than did their forebears many centuries ago.[13] These observers point to evidence of abandoned irrigation systems in the Sistan Depression (in southwest Afghanistan), in ancient Bactria (in the north of Afghanistan), and other regions of early settlement. The demise of these systems has been attributed to the destruction by Ghengis Khan, Tamerlane, and other conquerors; to changing weather patterns; and to misguided human behavior in applying water to the land.

Afghanistan's agriculture is significantly dependent on snow and rain that falls at high altitudes in the mountains. The amalgamation of mountain, steppe, and desert systems into a single political unit stems in large part from the water-based economic interdependence of these systems within the country. The mountains provide water without which lower regions would be primarily barren.

Donald Wilbur argues that water, in combination with topography, has governed the spatial distribution of Afghanistan's population. The narrow mountain valleys offer little room for the development of large communities. The waters carried by their rivers to the lower, more open regions have produced the largest human settlements of present-day Afghanistan:

> How decisive these geographic conditions have been is evident in the fact that since the time of Alexander the locations of most of the principal communities—Kabul, Qandahar, Ghazni, Herat, Mazar-i-Sharif, and Jalalabad - have remained unchanged.[14]

Wilber also views water constraints as a major factor in Afghan rural life, the manner of the distribution of this scarce resource representing a kind of litmus test of the viability and social cohesiveness of small communities:

> Water ranks with property and women as a source of dispute in Afghanistan. Where the supply is plentiful and justly shared, villages develop a high degree of cooperation and self-sufficiency, tightly bound by common interests.[15]

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[13]See, for example, Gregorian, V., *The Emergence of Modern Afghanistan* Stanford, California: Stanford University Press, 1969, pp. 17-20; Fraser-Tytler, W., *Afghanistan: A Study of Political Developments in Central and Southern Asia*, New York, NY: Paragon Books, 1967, p. 14; Dupree, L. *Afghanistan*, Princeton, NJ: Princeton University Press, 1980, p. 37.

[14]Wilbur, D. *Afghanistan*. New Haven: HRAF Press, 1962, p. 31,

[15]Wilber, *Afghanistan*, 1962, p. 136.

Given the rather rudimentary traditional irrigation technology used in much of Afghanistan, the pattern of agricultural production has been heavily dependent on the annual and seasonal incidence of precipitation. Where water is sufficient and temperature permits, there are two growing seasons: from late fall to early summer (winter crops) and from spring to summer (summer crops). Winter crops are wheat, barley, lentils, beans, peas, and melons. Summer crops are rice, tobacco, cotton, and other fruits. In general, the quantity of nonstaple and industrial crops depends on wheat production in the previous season. Dependency on wheat results primarily from uncertainties about rainfall and the lack of major water storage reservoirs. Relatively low wheat yields have been attributed not only to shortages of water but also to the limited availability of fertilizer and the absence of sufficient organic matter in soils in many parts of Afghanistan.

Water, as much or more than land, is the most critical resource in Afghan life. Afghans are preoccupied with water; with the amount that falls from the sky in the form of rain and snow and with the various processes used to transport water to farmlands. This preoccupation punctuates everyday talk.

Land, for instance, is linguistically categorized as irrigated, unirrigated but arable in years of normal rainfall, or barren wasteland. The watershed rather than the province or subprovince is the natural unit of rural life, and Afghans habitually discuss direction in terms of gravity flow: whether a given place is above or below the speaker according to the direction of the water flow. To an outsider certain regions may seem effectively flat, but residents have a subtle sense of relative elevation. Ordinary conversation is enlivened by parables and aphorisms that feature water as the central referent, the bottom line in traditional equations of success and failure.

Irrigation Technologies and Control Systems

The traditional irrigation systems developed by Afghans to capture and distribute available precipitation should be viewed in both a technical and sociopolitical context. Traditional systems lose considerable amounts of water as a result of their technological limitations and the seemingly archaic disputes in which their users are often involved. In contrast, these labor-intensive and relatively small-scale irrigation systems are manageable and repairable, given local cultural practices and capabilities. On the surface, at least, they appear to be more congruent with local culture and with the fragmented sociopolitical structures that are likely to predominate in Afghanistan than are more modern and larger-scale systems. Yet, after many mistakes and hard-learned lessons, the Helmand-Arghandab Valley Authority was able to achieve accommodations between requirements of irrigation systems and traditional practices in a number of regions. The capacity of

rural regions to support returning refugees reflects both technical and cultural considerations.

The most common of the traditional systems diverts riverine flows into a ramifying network of primary canals and capillary rivulets. Often the same river will supply several of these systems whose main diversion intakes are spaced irregularly along its length on both sides. The Konduz river, for example, spawns at least five primary canals between the towns of Baghlan and Konduz.

Each of these traditional main canal systems is self-organized and self-governed by an ad hoc, informal, collective structure whose members include all landowners receiving water. For the most part, this unit operates quite autonomously. There is little if any coordination among the main canals along a river, and the central government is actively involved only in the event of serious disputes.

The landowner group convenes at least once a year, always in late winter, to select a supervisor (*mirab*) to schedule necessary pregrowing season maintenance and to plan for the coming year according to the amount of accumulated Hindu Kush snowfall. The unfolding of events at this annual gathering depends on the sociopolitical disposition of the watershed, which is in turn often a reflection of ethnicity and kinship. With competition for scarce resources typically structured along ethnic lines, the meeting's initial spirit of solidarity can quickly deteriorate into a bitter argument. In the case of the Nahr-i-Aliabad along the Konduz River, the Pushtun clan of Omar Khel traditionally flexed its political muscle in *mirab* selections at the expense of the Lakai Uzbeks and other, smaller ethnic groups.

The stakes are high. A favorably disposed *mirab* will wink selectively (within the limits of what Louis Dupree termed "tolerable deviance") at the various forms of abuse that surface irrigation is vulnerable to: shirking the provision of maintenance labor or, much more serious, stealing water out of turn in the dry months of late summer and fall. Also at issue is the matter of where along the canal's length the *mirab* himself resides. Folk wisdom has it that the best *mirabs* are those whose own properties are located well downstream from the canal intake. Only with such a *mirab*, the people say, will water ever get that far during the dry season. A harsh fact of life of surface canal irrigation that those downstream are at a severe disadvantage. Whether those upstream take more than their share or whether water simply runs out, it is the owners downstream who must cope with the water shortage.

The *mirab* is typically a landowner himself, but not a great Khan. The most powerful elders do not themselves seek the position. They prefer someone else—a client, kinsman, or political ally—to perform this role. However, even in ethnically heterogeneous situations, the selection process usually results in a consensus whereby all parties are satisfied or at least

reconciled. Before the war, the nomination was submitted to provincial officials for approval. This approval was usually routinely granted where consensus has been successfully achieved.

Once the *mirab* is selected, the canal system for the growing system can be prepared. Maintenance of the small capillaries is the responsibility of those whose lands are directly affected, but all landowners are expected to supply labor and sometimes money toward this common effort. The amount of this levy varies according to the size of property to be watered. Typically, workers from the entire watershed meet at the canal's main intake point for one or more days of digging, canalizing, damming, and reinforcing. Tools and materials are locally available. Small landowners may come themselves; richer men send retainers or hired hands. As in virtually every other facet of traditional irrigation, this early phase creates its share of disputes. Did the owner send the requisite number of workers? Did they stay the entire day? On the basis of how many jeribs was that obligation calculated in the first place? Does the owner really own that much—or that little—land? Does he have a deed? Old disputes can quickly be revived and escalated. Before the war, disputes that could not be settled to general satisfaction could be taken by the *mirab* (or someone else) to the government. Or a delinquent land owner might pay a "fine" to the *mirab* who would then use that money to "rent" the services of a soldier for the day. The range of permutations was wide, all were designed to (1) complete the necessary work and (2) preserve a semblance of cooperation among those to share the water in the months to come.

During the growing season, the *mirab* is responsible for ongoing maintenance (in which he is assisted periodically by smaller work gangs), for developing and promulgating a schedule of water rotation, and for ensuring that this rotation sequence is followed up and down the watercourse. In policing the rotation sequence, he is assisted by a deputy who does most of the day-to-day legwork. All landowners are expected to contribute, again according to the size of the watered property, towards the salaries of these two men who are themselves responsible for collecting this money. Collection is said to be an uncertain process. A *mirab* whose work meets with approval throughout the watershed could make as much as Af. 100,000 (about $2,000) in the mid-1970's, but most pocketed considerably less. The position is a difficult one. Informants in the north reported that only 10 percent of *mirabs* served for more than a year.

During the late summer, particularly in dry years, this system of water distribution suffers the greatest stress. No statistics are available, but folk wisdom maintains that assault and murder rates peak in August. It takes only a few deft seconds with a shovel to illicitly open a mud and brush barrage. Nights are more dangerous in the late summer than during other seasons. To walk in the countryside after dark, however innocuously, invites suspicion. With their age-old faith in self-help as the quickest and surest recourse,

water-parched Afghan farmers observe few niceties in their defense of the prescribed water rotation sequence or, if need be, in the violation of it.

An array of technical limitations add to the problems of traditional surface irrigation. The main intakes may wash out in flood water at any time between February and June. Conversely, during extreme low water levels several months later, the same intake may be left useless high above the river that it was designed to tap. Long, slow, winding, and sluggish waterways encourage seepage and evaporation. For convenience, housing and orchards are often next to capillary ditches, making the ditches difficult to see and police from a distance. The most basic technical problem is the absence of any large-scale storage technology. Households may dig their own storage pools for domestic and limited agricultural use, but there are no reservoirs for the main canals.

Standards of efficiency for traditional irrigation fall short of western standards and those in more modern Afghan systems. The potential for dispute is always present. Technical weaknesses are obvious. Little or no coordination exists among canal systems up and down a long river. And yet, in its own fashion, the system works. Farmers know it, trust it, and perpetuate it with little dependence on the central government.

The southern half of Afghanistan is so hot in summer that water quickly evaporates from surface canals. Long-distance carriage of irrigation water is often accomplished by means of underground gravity flow aqueducts—*karezes* (Pashto) or *qanats* (Persian and Arabic). Figure 2-8 in Chapter 2 shows the distribution of *karezes* within the country. These devices tap the subterranean water table, usually at the foot of a hill or escarpment, and then proceed for long distances (more than 20 km) before finally emerging in the immediate vicinity of the region to be irrigated. Construction and maintenance of the underground tunnels is the work of part-time specialists (often an inherited responsibility) rather than a communal enterprise. The volume of *karez* flow is less than that of most surface canals, and the areas irrigated are correspondingly smaller, usually no more than a village or two at most. Technically, the *karez* would seem less cost-effective than its surface counterpart in terms of effort expended and water delivered, but weather and rapid evaporation render it the only practical option in certain regions. Because *karezes* require less communal cooperation, their use is less likely to cause disputes than is the case with canal systems.

Wells are the least popular system of traditional irrigation in Afghanistan; their limitations are significant. Few rural Afghan households own wells. Until recently, all well water was obtained by muscle power, usually human. Well-to-do farmers sometimes use well water to help irrigate kitchen gardens and orchards next to their compounds. Gasoline pumps have extended such uses somewhat but have also hastened the decline of local water tables. It has also been reported that wealthy farmers, using gasoline

pumps at favorable locations on streams and canals, have extracted more than their share of limited surface water resources.

For most of the post-World War II period, it was assumed by both the Afghan Government and expatriate planners that the future of irrigation lay in large-scale, capital intensive, technologically complex systems. The performance of these systems was mixed even before the onset of widespread political dislocation in the late 1970s. The past dozen years of war have shown how dependent such systems are on centralized control. Indeed, political stability is only one of several conditions required for the optimum operation of modern systems. Other conditions include (1) sufficient capital funds, (2) ongoing technical expertise, and (3) a receptive agriculturalist population. Given the current state of affairs in Afghanistan, those conditions do not appear probable in the near future. It is conceivable, however, that farmer willingness to accept the discipline and special requirements of modern irrigation systems has increased during the period of disruption caused by hostilities. It is one thing for a farmer to resist change from a traditional, if inefficient, system that continues to provide irrigation water. It is quite another to resist the restoration of a modern system that represents farmers' best hopes for survival.

The decentralization of authority that is characteristic of traditional systems is an attractive feature in times of political instability, just as the water delivery capabilities of modern systems are an attractive feature from the point of view of farm production and large-scale refugee return. Nevertheless, resettlement planners should be wary of being caught up in theoretical "small is beautiful" versus "big is better" general arguments concerning the proper scale of irrigation in developing countries. Investigations of conditions in the Helmand Valley suggest that a fusion of traditional and modern approaches is possible and that a number of significant improvements in a large-scale system can be made with community-related applications of appropriate technology.

As much as is practical, control over the rebuilding and subsequent operation of irrigation networks should be a local responsibility. The greater the extent of local involvement in decisions, the more likely it is that farmers will welcome and contribute to assistance programs. As for the question of whether Afghans would ever agree to pay for water, it should be noted that they do so traditionally in the form of labor and cash levies each spring, for maintenance as well as for *mirab* salaries. Water, they realize, has a cost like every other resource, and they recognize a need to pay for it. Problems arise when payment is required by outside authority whose good intentions and expertise are not automatically conceded by farmers.

will be required in order to construct new water storage and distribution facilities.

Projects for increasing the amount of irrigated agriculture in response to refugee return can be divided into four levels of priority.

- **First Priority** projects can be undertaken now with a minimum amount of planning and a low level of investment. They offer the quickest method of bringing additional irrigated lands into production.

- **Second Priority** water resources development projects were in progress and partially completed when hostilities started. These projects will require more investigation and preparation than First Priority projects, but will benefit from past experience.

- **Third Priority** is assigned to water resources projects that were still being planned when hostilities began.

- **Fourth Priority** is assigned to entirely new projects.

In the near term, opportunities for expanding agriculture, and therefore the numbers of additional people who can be supported, will be limited primarily to previously irrigated lands within regions with adequate year-round water supplies (the southern and northeastern regions). Meaningful expansion of irrigated agriculture beyond the 175,000 ha. of readily available land estimated for these regions will require significant additional planning and, consequently, greater lead times and investment.

Two points should be borne in mind as sociopolitical imperatives are integrated with economic and technical objectives and assessments of human needs. First, most needs for water arise at the farm, household, and community levels. Making allocation decisions on the basis of need averaged across large areas can do an injustice to have-not communities within regions that appear to have a surplus or approximate balance. Second, a multisectoral perspective is often best suited to circumstances in which sociopolitical considerations strongly affect resource allocation decisions. One area may be best served by upgraded water infrastructure, another by improved roads, a third by better health facilities. The wider and more flexible the menu of projects that can be practically offered and delivered, the more likely it is that multiple objectives can be achieved at a reasonable cost.

The principal recommendations of the Nathan-Berger team for further study, research, and training activities are as follows:

1. **Studies of local irrigation system conditions and potentials.** The project and regional priorities identified in this report were derived on the basis of a desk-top study, using information of

Effect of Precipitation Levels on Agricultural Production

Agriculture has been heavily dependent on annual mountain snow and rain for much of Afghanistan's history. However, evidence suggests that irrigation, high quality seeds, fertilizer, and technical advice can reduce this dependency. The levels of technology used can have a critical impact on the extent to which agricultural production is governed by the forces of nature.

Table 4-1 presents a comparison of changes in precipitation, wheat production, and livestock production over a 7-year period in the 1970s. The comparison suggests that the drought years of 1969-1970 and 1970-1971 had an immediate and very serious effect on wheat production and a somewhat less dramatic but more extended effect on livestock production.[16] In fact, the famine that followed these 2 years of drought reportedly resulted in the deaths of as many as 100,000 people. By contrast, the data in Table 4-1 do not show that the decline in precipitation in the less severe drought year of 1973-1974 had an appreciable effect on either wheat or livestock production.

The more extended decline in livestock production following the 2-year drought shown in Table 4-1 may result from relationships between agriculture and pastoralism as well as from the direct effects of dry years on Afghanistan's pasture lands.

Mixtures of pastoralism with limited migration and agriculture are common in Afghanistan.[17] In some groups, the village population moves from a "winter" agricultural location to a summer pastoral location, so that the entire community is engaged in crop raising and animal husbandry on a seasonal basis. In other groups, specialization occurs within the family, one brother farms the land while another cares for herds as a nomad. There is movement between the two occupations within and between generations. Over time family members and resources shift back and forth between farming and pastoralism in accordance with economic and environmental conditions. Laurie Krieger concludes:

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[16]Snow and rains occur principally in winter and spring months (see Chapter 2). Because the Afghan year runs from March to March, rains in a given chronological year are shown in the following year. In order to illustrate relationships more directly and avoid a complicated presentation, the data for wheat production in Table 7 have been moved up by 1 year. Thus the wheat -12.8 percent decline aligned with -25.4 percent decline in precipitation for 1969-1970 actually occurred in 1970-1971. In the case of livestock data (shown for the U.S. chronological year), the data have been moved up by 9 months.

[17]Krieger, L. "The Society and Its Environment," in *Afghanistan: A Country Study*. Washington, D.C.: U.S. Printing Office, 1986, p. 124-125.

Both pastoral nomadism and sedentary agriculture, then, are not necessarily permanent adaptations. The extremely varied ecology helps to determine which option is most viable in a given place at a given time.[18]

Table 4-1. Changes in Rainfall and Production (percentage of 7-year average)

Year	Precipitation (mm)	Wheat (000 MT)[a]	Livestock ($ millions)[b]
1968-1967	18.5	2.8	11.6
1969-1970	-25.4	-12.8	0.1
1970-1971	-32.2	-19.7	-5.0
1971-1972	27.0	2.7	-12.9
1972-1973	23.8	13.1	-3.2
1973-1974	-16.7	15.2	2.2
1974-1975	4.9	19.4	7.2
7-year average	351.9	2386.3	639.1

[a]Central Statistics Office data lagged 1 year.
[b]United States Department of Agriculture data lagged 9 months.
Source: Central Statistics Office.

Livestock represents a store of value, a "bank account on the hoof," that can be drawn on during hard times. Often it takes a farmer several years after the end of a drought to recover from the losses that it has caused. Conceivably, the decline in livestock income in the years following the low precipitation during 1969-1970 and 1970-1971 was caused by autoconsumption of livestock and drawing on wealth for reinvestment in agriculture as well as a reduction in the availability of good grazing lands and forage for the country's herds.

The data in Table 4-1 show that wheat and livestock production rose in the less severe drought of 1973-1974. In the years during and following the first drought of the decade, the government moved decisively to introduce the technology of the "Green Revolution," including fertilizers, new seed varieties, and agricultural extension in order to increase food production. It is likely that this technology, generally applied to the best watered lands, accounted for increased wheat production during this period of relatively low precipitation. There is, however, evidence of movement of smaller farmers off the land when the new technology was introduced.

[18]Krieger, L. *Afghanistan:A Country Study*, p. 125.

Human Carrying Capacity of the Land

Although water supply clearly operates as a key constraint to agricultural productivity in Afghanistan, that constraint becomes truly binding only in the context of weather cycles, applicable irrigation and agricultural technology, human technical and managerial skills, topography, soil types, and a variety of agronomic and economic conditions that can influence system delivery capabilities at critical points in time. The prospect of a large-scale refugee return to Afghanistan raises questions of the "human carrying capacity of the land" in their broadest context.

Analysis of carrying capacity is illustrated in a recent study carried out by the United States Geological Survey (USGS). As part of its CPSP process, USAID/Senegal asked the USGS to estimate the human population that could be supported by rainfed agriculture until 2010 under various scenarios.[19] The study integrated analyses of rainfall, climate, soils, land use, soil erosion, food and cash crops, range and forest resources, and population and sought to discover the development strategy that Senegal should follow in order to come to grips with the problems of population growth.

The prospective resettlement of Afghanistan poses human carrying capacity problems of a somewhat different character. The essential concern is irrigated rather than rainfed agriculture; the pivotal limitations are those of infrastructure, land location, and human behavior; the critical issue is human carrying capacity of the land in the next 5 to 10 years. Concerns include not only whether specific regions can produce sufficient food to sustain their populations but also whether they can do so using agricultural technologies that provide livelihoods for returning refugees.

This study is designed as a preliminary contribution to an understanding of this issue, focusing on the relatively narrow but very important question of whether Afghanistan's water resources are sufficient to support a large-scale refugee return. The water constraint analysis that follows uses available data to identify solutions and provide quantitative and qualitative assessments of problems that could potentially be caused by the inability to apply water effectively to the land.

Water Supply-Demand Analysis

The quantitative assessment presented in this chapter compares water supply with agricultural demand for water in Afghanistan. "Agricultural

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[19]Moore, D. et al., *Geographic Modelling of Human Carrying Capacity from Rainfed Agriculture*. Sioux Falls, S.D.: U.S. Geological Survey, 1991.

demand" represents the needs of specific crops raised in specific regions. Past and present conditions are assessed separately. Specific crops have distinctive water needs and time profiles. Delivery of water to root systems can be especially important at various stages in growing cycles. As in the case of the application of fertilizer, timing is important.

The analysis of water supply and agricultural demand compares estimated monthly and annual crop-water requirements with supply in the various regions of Afghanistan. The analysis defines individual watersheds and regional areas that are supplied by common watersheds. Annual and monthly water supply and crop demands are estimated for each region. Water supply and demand are then examined in each region and the implications discussed.

For the analysis of current conditions, the major change in model input is crop area. Estimates of irrigated crop area by province are derived from Swedish Committee for Afghanistan (SCA) data on crop yields and estimates of cereal crop production from the AFGRAIN model developed by Nathan-Berger in 1990. Crop areas are adjusted to match available countrywide crop statistics. The prewar and current water supply and demand situation is compared in each region to define the regional water situation and the potential constraints that might be imposed by water availability due to timing and volume of runoff.

Descriptions of the methodology and results follow.

Watershed Boundaries

The Nathan-Berger study team used available topographic mapping at a scale of 1:1,500,000 to define watershed areas for the major tributaries in the four major river systems: the Kabul, the Amu Darya, the Hari Rud, and the Helmand-Arghandab, as well as other regions that do not contribute flows to these rivers including the Ghazni-Sardeh closed basin, the rivers flowing into the Indus from Paktya and Paktyka, and the northern rivers that drain Samangan, Balkh, Jowzjan, and Faryab. Figure 4-1 shows watershed boundaries developed for each of the major tributaries by Nathan-Berger. The mapping was digitized to simplify computation of drainage regions and to allow the representation to be incorporated into a Geographic Information System (GIS) for Afghanistan being developed for O/AID/Rep by the Earth Satellite Corporation under its subcontract with Development Alternatives, Inc. Earthsat assigned numbers to the watersheds as shown in Figure 4-1 to allow referencing data, such as drainage region, associated with each watershed.

Boundaries of Regional Areas

Data on crop production are available only on the basis of political subdivisions. Watersheds and rivers do not often respect political boundaries, making definition of water availability by province quite difficult. In order to match water supply on the basis of watersheds more closely with agricultural data tabulated by province, larger regional areas were defined in which watershed and regional boundaries more closely coincide. Figure 2-7 shows the relationship between provinces, regional areas, and watershed boundaries. Table 4-2 tabulates the regional areas, their contributing watersheds and principal streams.

The Ghazni region (defined, in this case, by the Ghazni province boundaries), is a relatively high plateau region feeding many watersheds that did not fit well into this classification scheme. Water from only one watershed, No. 201, is included as supply for this region. All other watersheds draining through the region are included as supply elsewhere. Consequently, the water supply for the Ghazni region is probably underestimated, as will be illustrated in following sections.

Derivation of Monthly and Annual Water Supply

To derive an estimate of average monthly and annual surface water supply for each region, the Nathan-Berger team first computed flows for individual watersheds on the basis of historical streamflow data obtained from several sources[20]. Table 4-3 summarizes the stream gages used in the analysis. For watersheds with stream gages, flows were estimated for the entire watershed by multiplying the gaged flows by the ratio between total watershed area and watershed area at the gage site. In ungaged watersheds, flows were estimated by transposing flow data from similar gaged basins, and again, multiplying these flows by the ratio of ungaged and gaged drainage basin areas.

Total regional flows were computed by summing the monthly and annual flows for all the watersheds in the region.

Of all the regions, the Helmand-Arghandab and Hari Rud basins had the best gage coverage (most extensive areal coverage and longest gage record) and flows estimated here are believed to be the best. Where data coverage is not as extensive, estimates were made conservatively (low-side)

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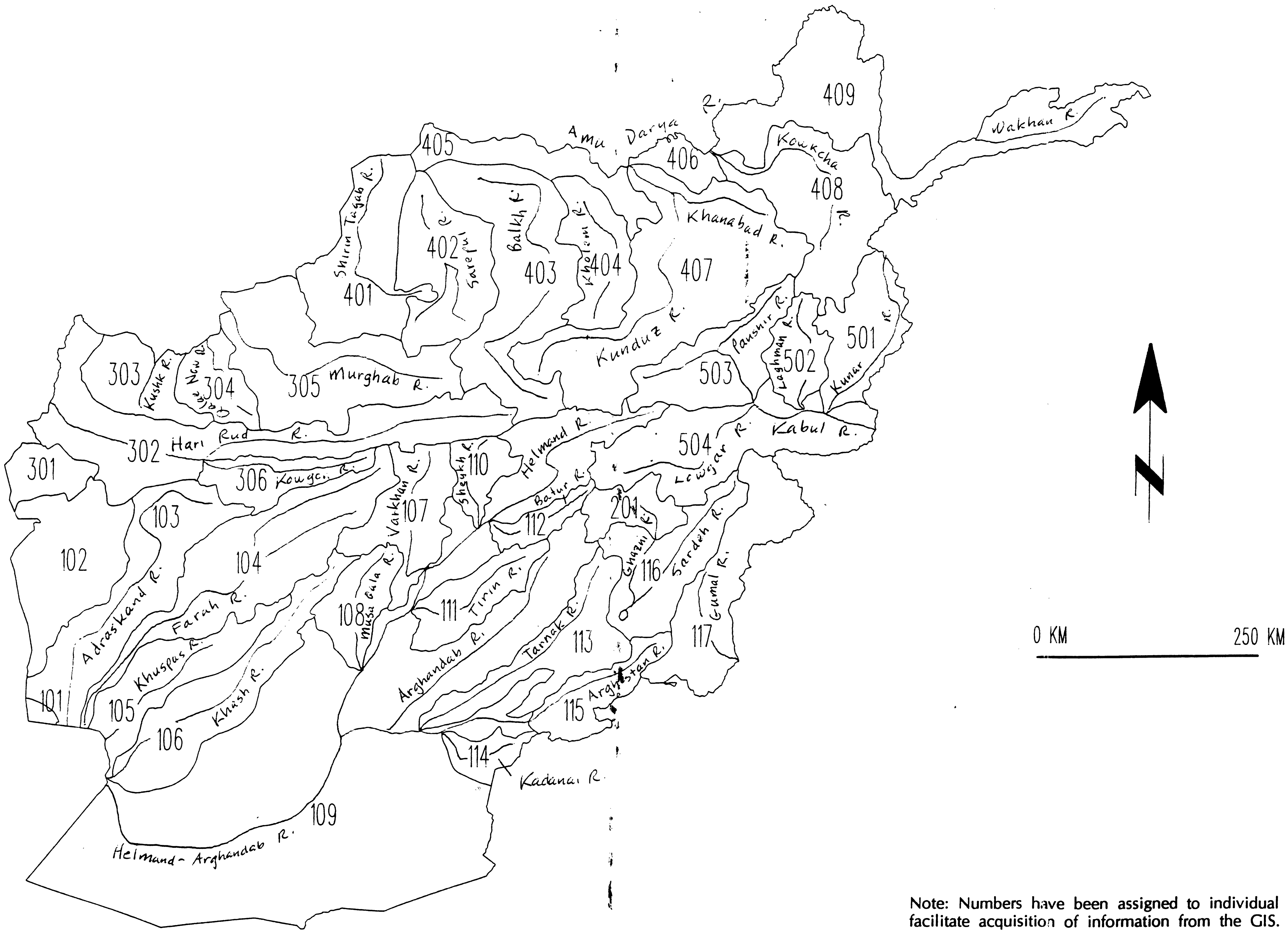
[20] *Survey of Land and Water Resources Afghanistan*, FAO, 1975; *Appraisal of Khanabad II Irrigation Project Afghanistan*, World Bank, 1978; Childers, D. *Compilation of Streamflow Records, Helmand River Valley and adjacent areas, Afghanistan, 1947-1973*, 1974.

Figure 4-1. Major Rivers and Watershed Areas



Note: Numbers have been assigned to individual watersheds to facilitate acquisition of information from the GIS.

Table 4-2. Regional Areas and Contributing Watersheds

Region	Provinces within Region	Watersheds Contributing Flow	Principal Streams
Western	Farah	101	Intermittent
		102	Intermittent
		103	Adraskand
		104	Farah
Southwestern	Nimroz	105	Khuspas
		106	Khash
Southern	Helmand,	107	Varkhan
	Qandahar,	108	Musa Qala
	Oruzgan, Zabul	109	Helmand-Arghandab
		110	Sheykh Miran
		111	Tirin
		112	Batur
		113	Tarnak
		114	Kadanai
		115	Arghestan
Southeastern	Paktya, Paktyka	116	Sardeh
		117	Gumal
Central	Ghazni	201	Ghazni
Eastern	Kabul, Logar,	501	Kunar
	Wardak,	502	Laghman
	Parwan, Kapisa,	503	Panshir-Ghorband
	Laghman,	504	Lowgar-Kabul
	Konar,		
	Nangarhar		
Northeastern	Badakshan,	406	Intermittent
	Bamian,	407	Kunduz-Khanabad
	Baghlan,		
	Konduz, Takhar	408	Kowkcha
		409	Wakhan
Northern	Samangan,	401	Shirin Tagab
	Balkh, Jawzjan,	402	Sarepul
	Faryab	403	Balkh
		404	Kholem
		405	Intermittent
Northwestern	Badghis, Herat,	301	Intermittent
	Ghor	302	Hari Rud
		303	Khushk
		304	Qala Now
		305	Murghad
		306	Kowgon

Source: Topographic maps by Nathan-Berger.

Table 4-3. Stream Gauging Stations Used in the Analysis

Gauging Station	Latitude	Longitude	Drainage Area (km^2)	Records Available
Adraskand River				
Ghazni River at Adraskand	33°38′	62°16′	2,070	1968
Adraskand River at Adraskand	33°38′	62°16′	1,930	1968
Farah River near Farah	32°33′	62°04′	26,900	1953-1968
Khash River near Dileram	32°10′	63°25′	5,380	1953-1967
Helmand-Arghandab River Basin				
Helmand River				
Helmand River above Kajakai Reservoir near Dehraout	32°41′	65°30′	35,480	1953-1968
Tirin River at Dehraout	32°40′	63°30′	5,590	1952-1968
Helmand River below Kajakai Dam	32°19′	65°06′	5,590	1952-1968
Musa Qala River at Musa Qala	32°20′	64°46′	3,750	1952-1968
Helmand River at Darweshan	31°01′	64°05′	131,300	1957-1968
Arghandab River above Arghandab Reservoir	32°01′	66°10′	16,950	1952-1968
Arghandab River below Arghandab Dam	31°51′	65°51′	17,800	1948-1968
Arghestan River near Kandarhar	31°26′	65°54′	17,150	1953-1968
Arghandab River near Qala-i-Best	31°33′	64°19′	65,800	1948-1968
Helmand River at Chahar Burjak	30°15′	62°00′	170,700	1947-1968
Helmand River at Shela Charkh	31°02′	61°52′	NA	1956-1968
Ghazni River below Saraj Dam	33°45′	68°23′	1,164	1948-1952
Paltu River above Sardi Reservoir, near Gardez	33°17′	68°48′	970	1949-1952
Amu Darya River Basin				
Andarab River at Doshi	33°37′	68°48′	NA	1965-1972
Kunduz River at Puli-Khumri	35°56′	68°43′	16,500	1950-1969
Kunduz River at Gerdab	NA	NA	NA	1964-1972
Kunduz River at Kolookh Tepa	NA	NA	NA	1966-1973
Kunduz River at Puli-Kunda Sang	NA	NA	NA	1968-1973
Khanbad River at Puli-Chugha	36°43′	69°10′	10,7000	1963-1975
Hari River Basin				
Hari River at Chekcheran	34°32′	65°16′	5,960	1962-1968
Hari River near Tagab Gaza	34°21′	63°39′	11,700	1968
Kowgon River at Langar	34°13′	63°00′	7,700	1963
Hari River at Puli-Pushtun	34°17′	62°13′	26,110	1963-1968
Kabul River Basin				
Kabul River at Tangi Saidan	34°25′	69°10′	1,900	1960-1966
Lowgar River at Kajaw	NA	NA	NA	NA
Lowgar River at Navishita	34°26′	69°16′	11,160	1961-1966

Note: NA denotes information not available.
Sources: *Survey of Land and Water Resources Afghanistan*, FAO, 1975; *Appraisal of Khanabad II Irrigation Project Afghanistan*, World Bank, 1978; Childers, D. *Compilation of Streamflow Records, Helmand River Valley and Adjacent Areas, Afghanistan, 1947-1973*, 1974.

and adjusted to conform with available annual flow data from various sources[21]. Table 4-4 summarizes the results of this analysis for each of the regional areas.

Accounting for Fallowed Land

In any given year, and depending on the perceived water supply conditions and past experience, farmers will fallow a certain amount of their irrigated crop lands. Farmers know that the water supply will probably not be adequate to irrigate all of their lands. Therefore, to maximize their efforts and yields, they must estimate the amount of land that can be successfully irrigated within the year and left fallow the rest.

For the purposes of this analysis, developing an estimate of the land actually irrigated necessitated an estimate of the total irrigated area in each province. This estimate is based on the preliminary Agricultural Census of Afghanistan, in 1969, revised by official sources to update the total irrigated area in each province to 1978-1979 conditions. Next, an estimate of the percentage of irrigated land fallowed in 1978-1979 by province is used to derive the actual area irrigated in 1978-1979. Table 4-5 summarizes this computation for each of the provinces.

Accounting for Groundwater Usage

About 16 percent of Afghanistan's total area irrigated is irrigated by underground water sources, including *karezes*, wells, and springs. Although the countrywide percentage is relatively low, in many provinces the area irrigated by groundwater makes up a significant portion of the total irrigated area as shown in Table 4-6. It is therefore necessary to consider groundwater in the regional water balance.

This is accomplished by computing the product of total irrigated land minus fallow and the percentage of land irrigated by each source.[22] Table 4-6 summarizes the percentages of groundwater and surface water usage for each province.

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[21] *Opportunities for Agriculture and Rural Development Sector Report*, World Bank, 1975; *First Seven-Year Economic and Social Development Plan*, Government of Afghanistan, Ministry of Planning, 1976; *Konar River Basin Development Master Plan Report*, Electrowatt, 1977.

[22] Ratios based on data from Statistics of Afghanistan, 1971-1972, Department of Statistics, Ministry of Planning.

distinctly limited currency, detail, and comprehensiveness. Assessments for particular regions—and for particular areas within those regions—may change as better, more complete, and more specific information becomes available. What is not likely to change, however, are the conclusions that water availability represents a serious constraint on resettlement in most of Afghanistan. It is important for political leaders and donors to have the best available knowledge of these constraints as they formulate policies, allocate funding, and make other decisions that affect the survival of returning refugees. Cross-border studies of the condition of local irrigation system and of the potential of specific regions to support returning refugees should be undertaken. Such studies can be initiated on a pilot basis.

2. **A framework for national water resource development.** Uncertainties about the magnitude, motivation, and pace of refugee return may tempt decision-makers to defer until later consideration of a basic plan for water resource development. However, ad hoc donor and government decisions made under the pressure of day-to-day developments could preempt rational long-term allocation of scarce resources—among watersheds and among such potentially competing requirements as irrigation and energy production. Enough information is available now to permit the development of a framework that would help decision-makers to also orient measures taken in immediate support of resettlement toward the achievement of longer-term water-development objectives.

3. **Urban water and sanitation systems studies: approach formulation.** Afghanistan's cities are currently overcrowded. Natural disasters and problems in the implementation of programs designed to return refugees to the countryside could cause further in-migration. With O/AID/Rep relocation in Kabul, the Mission will probably need to add a variety of urban projects to its program. Approaches to improving urban water supply and sanitation systems can be prepared before the refugees return and would represent a prudent investment in the future diversification of the Mission's portfolio.

4. **Training in Needed Skills.** Serious deficiencies in the design, planning, management, and operations have plagued Afghanistan's water resources development projects in the past. The implementability of second, third, and fourth priority projects may depend on human and organizational capacities in these areas. Short- and long-term approaches for providing such capacities should be formulated.

Table 4-4. Regional Water Supply

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean (m3/sec)	Ann. Tot. (millions m3
Subbasins Contributing to Farah Area															
sb101	avg monthly flow	0.00													
sb102	avg monthly flow	0.00													
sb103	avg monthly flow	10.24	12.90	19.08	32.10	57.01	177.46	93.13	173.83	23.81	9.40	5.09	8.12	51.85	1635.0
sb104	avg monthly flow	1.15	6.56	13.19	24.52	105.74	218.93	244.56	92.57	34.18	6.96	1.99	1.31	62.64	1975.4
total monthly flow (m3/sec)		11.39	19.46	32.27	56.63	162.75	396.39	337.68	266.40	57.99	16.36	7.09	9.43	114.49	3610.5
total monthly flow (millions m3)		30.5	50.5	86.4	151.7	393.7	1061.7	875.3	713.5	150.3	43.8	19.0	24.4	114.18	3600.8
Subbasins Contributing to Nimroz Area															
sb105	avg monthly flow	0.54	3.08	6.18	11.50	49.57	102.62	114.64	43.39	16.02	3.26	0.94	0.61	29.36	926.0
sb106	avg monthly flow	0.78	4.47	8.98	16.70	72.01	149.10	166.55	63.04	23.28	4.74	1.36	0.89	42.66	1345.3
total monthly flow (m3/sec)		1.32	7.55	15.17	28.20	121.58	251.72	281.19	106.44	39.30	8.01	2.29	1.50	72.02	2271.3
total monthly flow (millions m3)		3.5	19.6	40.6	75.5	294.1	674.2	728.8	285.1	101.9	21.4	6.1	3.9	71.50	2254.9
Subbasins Contributing to Helmand, Qandahar, Oruzgan, Zabul Area															
sb107	avg monthly flow	24.00	26.85	26.79	27.38	37.45	95.04	194.31	170.53	75.15	34.61	22.04	20.66	62.90	1983.6
sb108	avg monthly flow	0.76	2.21	5.57	5.89	19.30	58.61	54.85	18.98	4.20	2.21	0.68	0.62	14.49	456.9
sb109	avg monthly flow	85.51	88.11	95.41	104.47	88.12	11.21	97.55	290.83	164.48	125.73	126.77	100.75	114.91	3623.9
sb110	avg monthly flow	9.55	10.69	10.66	10.90	14.91	37.83	77.34	67.87	29.91	13.77	8.77	8.22	25.03	789.5
sb111	avg monthly flow	8.89	13.46	17.78	20.82	29.15	48.78	68.49	35.78	14.04	11.97	8.80	7.68	23.80	750.7
sb112	avg monthly flow	3.70	5.61	7.41	8.67	12.15	20.33	28.54	14.91	5.85	4.99	3.67	3.20	9.92	312.8
sb113	avg monthly flow	0.00	0.00	1.72	2.66	10.83	13.16	10.04	2.15	0.06	6.61	1.10	0.00	4.03	127.0
sb114	avg monthly flow	0.00	0.00	0.43	0.67	2.72	3.31	2.53	0.54	0.01	1.66	0.28	0.00	1.01	31.9
sb115	avg monthly flow	0.00	0.00	0.91	1.41	5.73	6.97	5.32	1.14	0.03	3.50	0.58	0.00	2.13	67.2
total monthly flow (m3/sec)		132.42	146.92	166.68	182.85	220.35	295.23	538.96	602.73	293.74	205.06	172.69	141.13	258.23	8143.5
total monthly flow (millions m3)		354.7	380.8	446.4	489.7	533.1	790.7	1397.0	1614.4	761.4	549.2	462.5	365.8	258.30	8145.8
Subbasins Contributing to Paktya, Paktyka Area															
sb116	avg monthly flow	9.75	14.72	17.23	17.27	16.14	23.94	57.11	31.18	8.31	6.14	6.86	5.31	17.83	562.3
sb117	avg monthly flow	12.08	18.25	21.35	21.40	19.99	29.66	70.77	38.64	10.30	7.61	8.51	6.58	22.09	696.7
total monthly flow (m3/sec)		21.82	32.97	38.57	38.68	36.13	53.60	127.87	69.82	18.61	13.75	15.37	11.89	39.92	1259.0
total monthly flow (millions m3)		58.4	85.5	103.3	103.6	87.4	143.6	331.4	187.0	48.2	36.8	41.2	30.8	39.87	1257.3
Subbasin Contributing to Ghazni Area															
sb201	avg monthly flow	6.71	10.34	12.25	12.34	11.22	14.67	22.96	14.71	3.68	2.98	4.05	3.45	9.95	313.6
total monthly flow (millions m3)		18.0	26.8	32.8	33.0	27.1	39.3	59.5	39.4	9.5	8.0	10.9	8.9	9.93	313.2
Subbasins Contributing to Badghis, Herat, Ghor Area															
sb301	avg monthly flow	0.00													
sb302	avg monthly flow	7.47	7.19	10.54	10.02	11.02	33.15	147.32	196.85	101.98	68.20	7.99	8.06	50.82	1602.5
sb303	avg monthly flow	3.83	5.25	5.38	5.60	7.76	14.41	26.30	20.96	4.90	1.65	1.58	2.75	8.36	263.7
sb304	avg monthly flow	2.84	3.90	3.99	4.16	5.76	10.70	19.53	15.56	3.64	1.23	1.17	2.04	6.21	195.9
sb305	avg monthly flow	11.28	15.46	15.85	16.49	22.87	42.46	77.52	61.75	14.43	4.87	4.65	8.10	24.64	777.2
sb306	avg monthly flow	3.19	4.37	4.48	4.66	6.46	12.00	21.91	17.45	4.08	1.38	1.31	2.29	6.97	219.7
total monthly flow (m3/sec)		28.61	36.16	40.24	40.93	53.88	112.72	292.58	312.58	129.02	77.32	16.70	23.24	97.00	3058.9
total monthly flow (millions m3)		76.6	93.7	107.8	109.6	130.3	301.9	758.4	837.2	334.4	207.1	44.7	60.2	97.10	3062.1

Table 4-4 (cont'd)

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean (m3/sec)	Ann. Tot. (millions m3
Subbasins Contributing to Samangan, Balkh, Jawzjan, Faryab Area															
sb401	avg monthly flow	18.38	25.19	25.82	26.87	37.26	69.19	126.30	100.62	23.51	7.93	7.58	13.19		
sb402	avg monthly flow	16.42	22.50	23.06	24.00	33.28	61.80	112.81	89.87	21.00	7.08	6.77	11.78	40.15	1266.3
sb403	avg monthly flow	26.73	36.62	37.54	39.07	54.17	100.58	183.62	146.28	34.17	11.53	11.02	19.18	35.86	1131.0
sb404	avg monthly flow	10.65	14.60	14.96	15.57	21.59	40.09	73.18	58.30	13.62	4.59	4.39	7.64	58.37	1840.9
sb405	avg monthly flow	0.00												23.27	733.7
total monthly flow (m3/sec)		72.18	98.91	101.39	105.52	146.29	271.65	495.91	395.08	92.29	31.13	29.75	51.80	157.66	4971.9
total monthly flow (millions m3)		193.3	256.4	271.6	282.6	353.9	727.6	1285.4	1058.2	239.2	83.4	79.7	134.3	157.46	4965.5
Subbasins Contributing to Badakshan, Bamian, Baghlan, Kunduz, Takhar Area															
sb406	avg monthly flow	0.00													
sb407	avg monthly flow	106.43	106.43	100.49	90.04	84.75	91.98	127.07	234.39	502.33	297.35	151.70	83.08		
sb408	avg monthly flow	56.25	56.25	53.12	47.59	44.80	48.62	67.16	123.89	265.51	157.16	80.18	43.91	164.67	5193.0
sb409	avg monthly flow	81.31	81.31	76.77	68.79	64.75	70.27	97.07	179.07	383.76	227.16	115.90	63.47	87.04	2744.8
														125.80	3967.3
total monthly flow (m3/sec)		243.98	243.98	230.38	206.42	194.30	210.86	291.30	537.35	1151.59	681.67	347.78	190.45	377.51	11905.0
total monthly flow (millions m3)		653.5	632.4	617.0	552.9	470.0	564.8	755.0	1439.2	2984.9	1825.8	931.5	493.7	378.01	11920.8
Subbasins Contributing to Kabul, Logar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar Area															
sb501	avg monthly flow	271.55	452.34	462.84	537.11	478.59	537.11	1277.50	798.16	170.28	96.02	79.52	159.78		
sb502	avg monthly flow	27.01	44.99	46.03	53.42	47.60	53.42	127.05	79.38	16.94	9.55	7.91	15.89	443.40	13983.1
sb503	avg monthly flow	55.34	92.19	94.33	109.46	97.54	109.46	260.36	162.67	34.70	19.57	16.21	32.56	44.10	1390.7
sb504	avg monthly flow	93.88	156.38	160.01	185.69	165.46	185.69	441.66	275.94	58.67	33.20	27.49	55.24	90.37	2849.8
														153.29	4834.2
total monthly flow (m3/sec)		447.79	745.90	763.21	885.68	789.19	885.68	2106.57	1316.14	280.79	158.33	131.12	263.48	731.16	23057.7
total monthly flow (millions m3)		1199.3	1933.4	2044.2	2372.2	1909.2	2372.2	5460.2	3525.2	727.8	424.1	351.2	682.9	729.39	23001.9

Source: Analysis of regional water supply by Nathan/Berger team.

TOTAL 58522.3

Table 4-5. Fallowed Irrigated Land

Region and Province	Irrigated Crop Area 1978-1979 (ha.)	Irrigated Crop Area 1989-1990 (ha.)	1978-1979		1989-1990	
			Percent Fallow	Area (ha.)	Percent Fallow	Area (ha.)
West						
Farah	131,507	100,745	35	46,027	45	45,335
Southwest						
Nimroz	66,253	35,961	34	22,526	48	17,261
Southern						
Helmand	196,950	143,191	31	61,055	40	57,276
Qandahar	138,249	114,107	28	38,710	37	42,220
Oruzgan	130,627	125,161	26	33,963	37	46,310
Zabul	67,689	44,011	10	6,769	38	16,724
Subtotal	533,515	426,470	26	140,496	38	162,530
Southeastern						
Paktya	39,538	36,709	10	3,954	34	12,481
Paktika	57,945	46,976	15	8,692	48	22,548
Subtotal	97,483	83,685	13	12,646	42	35,030
Central						
Ghazni	85,414	78,324	12	10,250	27	21,147
Eastern						
Kabul	60,927	59,928	6	3,656	14	8,390
Logar	32,772	24,520	11	3,605	34	8,337
Wardak	29,833	27,728	11	3,282	11	3,050
Parwan	41,637	35,958	5	2,082	6	2,157
Kapisa	46,606	52,797	10	4,661	2	1,056
Laghman	41,101	42,753	4	1,644	5	2,138
Konar	37,687	39,922	4	1,507	5	1,996
Nangarhar	70,300	57,923	6	4,218	11	6,372
Subtotal	360,863	341,529	7	24,654	10	33,496
Northeastern						
Badakshan	65,760	62,123	14	9,206	28	17,394
Bamian	27,201	25,680	8	2,176	23	5,906
Baghlan	92,065	89,089	32	29,461	38	33,854
Kunduz	215,153	155,083	21	45,182	40	62,033
Takhar	66,366	66,936	22	14,601	30	20,081
Subtotal	466,545	398,911	22	100,626	35	139,269
Northern						
Samangan	48,363	47,232	11	5,320	20	9,446
Balkh	229,510	174,470	20	45,902	38	66,299
Jawzjan	188,130	133,672	22	41,389	40	53,469
Faryab	123,014	460,910	21	122,134	36	165,096
Subtotal	589,017	460,910	21	122,134	36	165,096
Northwestern						
Badghis	40,346	35,737	14	5,648	26	9,292
Herat	172,552	131,664	15	25,883	28	36,866
Ghor	35,505	36,063	50	17,753	60	67,195
Subtotal	248,403	202,464	20	49,284	33	67,195
Total	2,579,000	2,129,000	20	528,643	32	686,359

Sources: *Afghanistan: Current Economic Situation,* World Bank, 1971. *Statistical Yearbook,* Department of Statistics, Ministry of Planning, 1980.

Table 4-6. Ground and Surface Water Supply, 1978-1979

Region and Province	Total Irrigated Crop Area	Total Irrigated Land Minus Fallow Land (ha.)	Groundwater ha.	Groundwater %	Surface Water ha.	Surface Water %	Groundwater Total 1989-1990 (ha.)
West							
Farah	131,507	85,479	35,046	41	50,432	59	31,541
Southwest							
Nimroz	66,253	43,726	437	1	43,289	99	393
Southern							
Helmand	196,950	135,895	23,102	17	112,793	83	20,792
Qandahar	138,249	99,539	18,912	19	80,626	81	17,021
Oruzgan	130,627	96,663	57,998	60	38,665	40	52,198
Zabul	67,689	60,920	24,368	40	36,552	60	21,931
Subtotal	533,515	393,018	124,381	31	268,637	68	111,943
Southeastern							
Paktya	39,538	35,584	8,540	24	27,043	76	7,686
Paktika	57,945	49,253	16,746	34	32,507	66	15,071
Subtotal	97,483	84,837	25,286	29	59,551	70	22,757
Central							
Ghazni	85,414	75,164	20,294	27	54,869	73	18,264
Eastern							
Kabul	60,927	57,271	18,899	33	38,371	67	17,009
Logar	32,772	29,167	3,208	11	25,958	89	2,887
Wardak	29,833	26,551	11,151	42	15,399	58	10,036
Parwan	41,637	39,555	9,493	24	30,061	76	8,543
Kapisa	46,606	41,945	4,194	10	37,750	90	3,775
Laghman	41,101	39,456	0	0	39,456	100	0
Konar	37,687	36,179	1,085	3	35,094	97	976
Nangarhar	70,300	66,082	21,146	32	44,935	68	19,031
Subtotal	360,863	336,208	69,178	20	267,029	79	62,261
Northeastern							
Badakshan	65,760	56,553	5,089	9	51,463	91	4,580
Bamian	27,201	25,024	8,007	32	17,016	68	7,207
Baghlan	92,065	62,604	0	0	62,604	100	0
Kunduz	215,153	169,970	0	0	169,970	100	0
Takhar	66,366	51,765	7,247	14	44,518	86	6,522
Subtotal	466,545	365,919	20,344	5	345,574	74	18,310
Northern							
Samangan	48,363	43,043	6,456	15	36,586	85	5,810
Balkh	229,510	183,608	0	0	183,608	100	0
Jawzjan	188,130	146,741	1,467	1	145,274	99	1,320
Faryab	123,014	93,490	3,739	4	89,751	96	3,365
Subtotal	589,017	466,883	11,663	2	455,219	97	10,497
Northwestern							
Badghis	40,346	34,697	14,225	41	20,471	59	12,803
Herat	172,552	146,669	2,933	2	143,735	98	2,640
Ghor	35,505	17,752	9,408	53	8,343	47	8,467
Subtotal	248,403	199,119	26,568	13	172,551	86	23,911
Total	2,579,000	2,050,357	333,201	16	1,717,156	83	299,881

Source: Statistics of Afghanistan, 1971-1972, Department of Statistics, Ministry of Planning.

Currently, 16 percent of Afghanistan's irrigated land is estimated to be supplied by groundwater. Approximate percentages of sources are as follows.

Source	*Percentage*
Springs	8
Karezes	7
Wells	1
Subtotal	16

Considerable effort has been devoted to the rehabilitation of karezes: restoration of the capabilities of these specialized structures may have reached a point of diminishing returns. It is theoretically possible that additional springs could be found and utilized and that the percentage of the land watered by wells on land not irrigable from surface sources could be increased through the use of motor-driven pumps, but such prospects are largely speculative and on-the-spot investigations would be required to establish relevant potentials.

Apart from estimates of areas of land irrigated by groundwater, there is very little useful information available on groundwater resources in Afghanistan. Studies of Afghanistan's groundwater resources have, in general, been preliminary, fragmentary, and incomplete [23]. Before the war, hydrological surveys conducted were carried out in the Kabul and Logar basins, Katawaz, Ghazni, the Zabul Shorabak district of Kandahar Province, Dasht-i-Bakwa, the Helmand Valley, and the main Hari Rud valley. Some of these preliminary studies were quite optimistic[24], but others identified serious existing or potential problems, including groundwater depletion[25]. In some areas there were indications that the development of deep groundwater sources might upset the operations of the traditional karez system. Prior

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[23]Neal E. McClymonds, *Shallow Ground Water in the Zamin Dawar Area, Helmand Province, Afghanistan.* Washington D.C.: U.S. Geological Survey Open File, 1972. Ata Monhammad Nazar, *Risk Avoidance in the Operation of a Water Supply System* (Qalagai Project in Afghanistan), Doctoral Dissertation. Fort Collins, Colorado: Colorado State University, August 1979 (pp. 142-145). Edward A. Sammel, *Ground Water Reconnaissancein the Arghandab River Basin near Kandahar, Afghanistan.* Washington D.C.: U.S. Geological Survey Open File, December 1971. Mark Svendsen, *Some Aspects of Irrigation Technology in Afghanistan.* Fort Collins, Colorado: Colorado State University Civil Engineering Department, January, 1977 (pp. 22-23).

[24]See Food and Agriculture Organization of the United Nations, *Survey of Irrigation Possibilitiesin the Hari Rud and Upper Kabul Basins.* Rome: FAO, 1970 (pp. 67-68).

[25]Leonard Schiff, *Irrigated Agriculture in Afghanistan.* Minneapolis, Minnesota: Experience Incorporated, December 1978, Annexes 1 and 2.

studies almost universally concluded that much more investigation was needed.[26]

Most groundwater in Afghanistan is drawn from subsurface water tables fed by and otherwise closely linked to river systems carrying snow-melt and precipitation from Afghanistan's mountains to its lowlands. In the long run, the prospects for the *joint* use of surface and groundwater resources may well have considerable potential in the Hari Rud River Basin, in some parts of the Helmand-Arghandab area, and perhaps some other locations in Afghanistan. Joint use poses serious technical, economic, and regulatory problems at the same time that it presents considerable opportunities.[27]

Groundwater development in areas where joint use of surface and groundwater for irrigation is technically feasible can increase system efficiency and reduce environmental problems. It may also offer substantial opportunities for creating a private sector well-drilling industry. However, joint use of surface and groundwater for irrigation is likely to further complicate problems of watershed resource allocation, potentially placing downstream users at a further disadvantage. Systems for joint use of surface and groundwater resources are best introduced in areas where institutional arrangements for water allocation work well.

In the absence of new detailed studies, the greatest potential sources for new groundwater development appear largely to overlap with some, but by no means all, areas irrigable by surface water in Afghanistan. However, the best short-term prospects for the development of groundwater resources may well lie in the use of groundwater for city and village water supply rather than for irrigation.

Derivation of Monthly and Annual Crop-Water Demand

To develop estimates of water demand for the regions, the irrigated land area within each province is divided into areas of irrigated wheat, maize, rice, and barley (the dominant cereal crops) and "other" crops (all remaining irrigated crops, including cotton, vegetables, and fruits) on the basis

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[26]James R. Jones, *Program of Ground Water Resources Investigation for the Helmand-Arghandab Valley Authority, Afghanistan*. Washington D.C.: U.S. Geological Survey Open File, December 1971 (pp. 1-2).

[27]Gerald O'Mara, ed.," *Efficiency in Irrigation: The Conjunctive Use of Surface and Groundwater Resources* Washington, D.C.: The World Bank, 1988. This report of a World Bank symposium held in 1983 examines experience with respect to the joint use of surface and groundwater resources in the Indus Valley of Pakistan, the North China Plane, and California.

of SCA data on crop yields, estimates of crop production from the Nathan-Berger AFGRAIN report, and other sources[28]. Table 4-7 provides the estimates for cereal crop areas by province and countrywide.

Monthly and total annual water demand for wheat, maize, and rice are averaged on the basis of water consumption data for these crops taken from irrigation project feasibility and appraisal studies in the major geographical regions.[29] Table 4-8 gives monthly and annual crop-water demand values derived for these three crops. Barley is not a high-value crop; it is grown primarily to feed livestock. It is therefore not included in any of the feasibility study agricultural schemes. Water demand for barley is close to that for wheat, however, and is therefore assumed to be the same.

Monthly and total annual water demand for "other" crops is assumed to be the same as for corn, a relatively high demand crop.

Water demand for each crop type is computed by multiplying crop monthly water demand values in (m^3 per ha.) by estimated crop area (ha.). Total monthly demand for a region is the sum of the individual crop demands of the region.

Accounting for System Losses

Irrigation systems in Afghanistan are quite inefficient; modern system losses of 50 percent are common. In traditional systems, losses as high as 70 and 80 percent have been documented. Losses occur in canals, in laterals, and through inefficient irrigation practices on individual farm.[30]

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[28]*The Agricultural Survey of Afghanistan, Third Report Crops and Yields*, Swedish Committee of Afghanistan, 1989; *AFGRAIN Afghanistan Regional Foodgrain Situation*, Nathan-Berger, 1990.

[29]Assifi, A.T. *Helmand Valley Shamalan Land Development Project Plans*, 1970; *Appraisal of Khanabad II Irrigation Project Afghanistan*, World Bank, 1978; *Survey of Land and Water Resources Afghanistan*, FAO, 1975.

[30]Assifi, A.T. *Helmand Valley Shamalan Land Development Project Plans*, 1970.

Table 4-7. Approximate Irrigated Crop Areas, 1978-1979 (ha.)

Region and Province	Wheat	Rice	Maize	Barley	Estimate of Total Irrigated Grain	Other Crops	Estimate of Total Irrigated Area
West:							
Farah	40,667	3,500	69,183	2,557	115,907	15,600	131,507
Southwest:							
Nimroz	32,231	0	25,685	1,537	59,453	6,800	66,253
Southern:							
Helmand	84,967	0	74,883	0	159,850	37,100	196,950
Qandahar	62,732	0	41,396	1,621	105,749	32,500	138,249
Oruzgan	50,411	12,802	52,622	4,192	120,027	10,600	130,627
Zabul	56,889	3,500	0	0	60,389	7,300	67,689
total	254,999	16,302	168,901	5,813	446,015	87,500	533,515
Southeastern:							
Paktya	17,225	2,000	13,513	0	32,738	6,800	39,538
Paktika	14,712	0	38,733	0	53,445	4,500	57,945
	31,937	2,000	52,246	0	86,183	11,300	97,483
Central:							
Ghazni	42,861	0	24,620	1,433	68,914	16,500	85,414
Eastern:							
Kabul	43,927	0	1,000	0	44,927	16,000	60,927
Logar	13,806	2,500	8,866	0	25,172	7,600	32,772
Wardak	17,047	4,000	2,000	1,286	24,333	5,500	29,833
Parwan	23,637	0	1,000	0	24,637	17,000	41,637
Kapisa	32,479	4,600	2,000	1,527	40,606	6,000	46,606
Laghman	12,600	14,000	8,101	0	34,701	6,400	41,101
Konar	11,700	4,400	14,446	1,141	31,687	6,000	37,687
Nangarhar	24,600	15,000	12,600	0	52,200	18,100	70,300
total	179,796	44,500	50,013	3,954	278,263	82,600	360,863
Northeastern:							
Badakshan	36,605	1,000	9,997	6,558	54,160	11,600	65,760
Bamian	16,388	1,100	0	1,913	19,401	7,800	27,201
Baghlan	29,965	37,600	0	0	67,565	24,500	92,065
Kunduz	108,081	57,498	0	1,274	166,853	48,300	215,153
Takhar	35,436	14,500	2,503	2,927	55,366	11,000	66,366
total	226,475	111,698	12,500	12,672	363,345	103,200	466,545

Table 4-7 (cont'd)

Region and Province	Wheat	Rice	Maize	Barley	Estimate of Total Irrigated Grain	Other Crops	Estimate of Total Irrigated Area
Northern:							
Samangan	33,972	0	2,965	1,726	38,663	9,700	48,363
Balkh	134,556	19,200	15,871	10,783	180,410	49,100	229,510
Jawzjan	113,991	0	16,870	32,769	163,630	24,500	188,130
Faryab	77,882	0	12,495	12,637	103,014	20,000	123,014
total	360,401	19,200	48,201	57,915	485,717	103,300	589,017
Northwestern:							
Badghis	15,170	3,200	12,463	1,313	32,146	8,200	40,346
Herat	97,616	9,600	5,036	11,800	124,052	48,500	172,552
Ghor	17,847	0	13,152	1,006	32,005	3,500	35,505
total	130,633	12,800	30,651	14,119	188,203	60,200	248,403
TOTAL	1,300,000	210,000	482,000	100,000	2,092,000	487,000	2,579,000

Sources: The Agricultural Survey of Afghanistan, Third Report Crops and Yields, the Swedish Committee of Afghanistan, 1989; AFGRAIN Afghanistan Regional Foodgrain Situation, Nathan–Berger, 1990; World Bank, The Journey to Economic Development, 1978 Vol. II, Table 7.4; GOA, Ministry of Planning, Seven Year Plan, 1976–77, Vol. 2, p.156; DRA, State Planning Committee, Socio-Economic Development Plan, 1986–87, March 1986, pp. 101–113.

Table 4-8. Crop-Water Demand (m^3 per ha.)

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Total
Wheat	620	290	90	60	140	310	640	800	180	0	0	0	3130
Maize	300	0	0	0	0	0	390	680	1810	1800	1190	420	6590
Rice	0	0	0	0	0	0	0	350	3410	2530	2540	810	9640

Source: A.T. Assifi, *Helmand Valley Shamalan Land Development Project Plans*, 1970; *Appraisal of Khanabad II Irrigation Project Afghanistan*, World Bank, 1978; *Survey of Land and Water Resources Afghanistan*, Food and Agriculture Organization, 1975.

For this analysis, 50 percent losses are assumed for computing the difference between supply and demand. At first glance, this value may seem low given the fact that about 90 percent of irrigation is by traditional means. However, 50 percent has been chosen because of the regional nature of the analysis. Although losses on individual systems can be as high as 80 percent, this water is *not* lost to the region and, in fact, is often used over and over again. This is because much of the water loss in these systems is the result of deep percolation. A portion of this water eventually drains back to the surface water system and is available for reuse. The 50 percent loss factor is an attempt to account for this characteristic. The approach and overall loss factor were discussed with an ex-HAVA water official who confirmed both.[31] Results of the analysis for each of the regions are summarized in Table 4-9.

Since the 50 percent loss factor has been projected uniformly for every region, the results of the analysis are highly sensitive to any substantial differential variations in this factor which may occur among regions. However, since it seems unlikely that losses will be any less than 50 percent, the principal concern is that losses would be greater. The impact of higher losses on the results for water-short regions would be increased irrigation deficits and the possibility that the period of shortage would expand. These eventualities would not affect the basic conclusion for the areas; that water storage facilities are needed to expand irrigated agriculture. In surplus areas (the Southern and Northeastern regions), higher loss factors would reduce the estimates for additional population supported. However, the magnitude of the supply surpluses in these two regions indicate that some level of expansion of irrigated agriculture is likely to be possible. The model indicates that losses of approximately 80 and 90 percent can be sustained in both of these regions before significant deficits occur.

Regional cropping patterns differ significantly and have been accounted for to the extent possible with available country and provincial data. Errors in areal estimates of the high water demand crops, such as rice, would have the greatest impact on analysis results. However, experience with the model indicates that errors of approximately 40 to 60 percent can occur before basic conclusions are affected. The data for Table 4-9 and the

[31]Interview with A.T. Assifi, January, 1992.

For the short term, particular attention should be given to (a) identifying and recruiting Afghans with prior water systems experience; (b) upgrading the skills of mirabs and lead farmers; and (c) filling gaps in capability through temporary assignments of foreign technical personnel where there is no other satisfactory alternative. A long-term training program should be designed to create the indigenous technical and managerial capabilities needed to plan and operate Afghanistan's water systems effectively. The program should include training of water users, mirabs, and (where appropriate) water-user association staff, project operation and management staff, and senior project management staff.

Table 4-9. Regional Supply and Demand for Prewar Conditions

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean (m3/sec)	Ann. Tot. (mill. m3)
Subbasins Contributing to Farah Area															
sb101	avg monthly flow	0.00													
sb102	avg monthly flow	0.00													
sb103	avg monthly flow	10.24	12.90	19.08	32.10	57.01	177.46	93.13	173.83	23.81	9.40	5.09	8.12	51.85	1635.0
sb104	avg monthly flow	1.15	6.56	13.19	24.52	105.74	218.93	244.56	92.57	34.18	6.96	1.99	1.31	62.64	1975.4
total monthly flow (m3/sec)		11.39	19.46	32.27	56.63	162.75	396.39	337.68	266.40	57.99	16.36	7.09	9.43	114.49	3610.5
total monthly flow (millions m3)		30.5	50.5	86.4	151.7	393.7	1061.7	875.3	713.5	150.3	43.8	19.0	24.4	114.18	3600.8
monthly demand wheat		10.3	4.8	1.5	1.0	2.3	5.1	10.6	13.3	3.0	0.0	0.0	0.0		51.9
monthly demand other		1.8	0.0	0.0	0.0	0.0	0.0	2.3	4.1	10.8	10.8	7.1	2.5		39.4
monthly demand maize		8.0	0.0	0.0	0.0	0.0	0.0	10.3	18.0	48.0	47.8	31.6	11.1		174.8
monthly demand rice		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.6	3.4	3.4	1.1		12.9
total monthly demand (millions m3)		20.0	4.8	1.5	1.0	2.3	5.1	23.3	35.8	66.4	61.9	42.1	14.7		279.1
total gross demand (n=0.50)		40.1	9.6	3.0	2.0	4.6	10.3	46.6	71.7	132.8	123.8	84.2	29.5		558.2
Ratio of Supply to Demand		76.2%	524.8%	2897.1%	7624.9%	8482.9%	10330.6%	1879.1%	995.4%	113.2%	35.4%	22.5%	82.9%		645.1%
Supply – Demand (millions m3)		–9.6	40.8	83.5	149.7	389.1	1051.4	828.7	641.8	17.5	–80.0	–65.2	–5.1		3042.6
Subbasins Contributing to Nimroz Area															
sb105	avg monthly flow	0.54	3.08	6.18	11.50	49.57	102.62	114.64	43.39	16.02	3.26	0.94	0.61	29.36	926.0
sb106	avg monthly flow	0.78	4.47	8.98	16.70	72.01	149.10	166.55	63.04	23.28	4.74	1.36	0.89	42.66	1345.3
total monthly flow (m3/sec)		1.32	7.55	15.17	28.20	121.58	251.72	281.19	106.44	39.30	8.01	2.29	1.50	72.02	2271.3
total monthly flow (millions m3)		3.5	19.6	40.6	75.5	294.1	674.2	728.8	285.1	101.9	21.4	6.1	3.9	71.50	2254.9
monthly demand wheat		13.7	6.4	2.0	1.3	3.1	6.8	14.1	17.7	4.0	0.0	0.0	0.0		69.1
monthly demand other		1.3	0.0	0.0	0.0	0.0	0.0	1.7	3.0	8.0	8.0	5.3	1.9		29.3
monthly demand maize		5.0	0.0	0.0	0.0	0.0	0.0	6.5	11.4	30.4	30.2	20.0	7.0		110.6
total monthly demand (millions m3)		20.0	6.4	2.0	1.3	3.1	6.8	22.4	32.1	42.4	38.2	25.3	8.9		208.9
total gross demand (n=0.50)		40.1	12.8	4.0	2.6	6.2	13.7	44.8	64.2	84.8	76.4	50.5	17.8		417.9
Ratio of Supply to Demand		8.8%	152.9%	1023.0%	2852.3%	4760.8%	4928.6%	1626.9%	444.3%	120.1%	28.1%	12.2%	21.8%		539.6%
Supply – Demand (millions m3)		–36.6	6.8	36.7	72.9	287.9	660.5	684.0	220.9	17.1	–55.0	–44.4	–13.9		1837.0
Subbasins Contributing to Helmand, Qandahar, Oruzgan, Zabul Area															
sb107	avg monthly flow	24.00	26.85	26.79	27.38	37.45	95.04	194.31	170.53	75.15	34.61	22.04	20.66	62.90	1983.6
sb108	avg monthly flow	0.76	2.21	5.57	5.89	19.30	58.61	54.85	18.98	4.20	2.21	0.68	0.62	14.49	456.9
sb109	avg monthly flow	85.51	88.11	95.41	104.47	88.12	11.21	97.55	290.83	164.48	125.73	126.77	100.75	114.91	3623.9
sb110	avg monthly flow	9.55	10.69	10.66	10.90	14.91	37.83	77.34	67.87	29.91	13.77	8.77	8.22	25.03	789.5
sb111	avg monthly flow	8.89	13.46	17.78	20.82	29.15	48.78	68.49	35.78	14.04	11.97	8.80	7.68	23.80	750.7
sb112	avg monthly flow	3.70	5.61	7.41	8.67	12.15	20.33	28.54	14.91	5.85	4.99	3.67	3.20	9.92	312.8
sb113	avg monthly flow	0.00	0.00	1.72	2.66	10.83	13.16	10.04	2.15	0.06	6.61	1.10	0.00	4.03	127.0
sb114	avg monthly flow	0.00	0.00	0.43	0.67	2.72	3.31	2.53	0.54	0.01	1.66	0.28	0.00	1.01	31.9
sb115	avg monthly flow	0.00	0.00	0.91	1.41	5.73	6.97	5.32	1.14	0.03	3.50	0.58	0.00	2.13	67.2
total monthly flow (m3/sec)		132.42	146.92	166.68	182.85	220.35	295.23	538.96	602.73	293.74	205.06	172.69	141.13	258.23	8143.5
total monthly flow (millions m3)		354.7	380.8	446.4	489.7	533.1	790.7	1397.0	1614.4	761.4	549.2	462.5	365.8	258.30	8145.8
monthly demand wheat		82.5	38.6	12.0	8.0	18.6	41.3	85.2	106.5	24.0	0.0	0.0	0.0		416.5
monthly demand other		14.2	0.0	0.0	0.0	0.0	0.0	18.4	32.2	85.6	85.1	56.3	19.9		311.6
monthly demand maize		24.8	0.0	0.0	0.0	0.0	0.0	32.2	56.2	149.5	148.7	98.3	34.7		544.4
monthly demand rice		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	19.4	14.4	14.4	4.6		54.7
total monthly demand (millions m3)		121.5	38.6	12.0	8.0	18.6	41.3	135.8	196.8	278.4	248.2	169.0	59.2		1327.2
total gross demand (N=0.50)		242.9	77.2	24.0	16.0	37.3	82.5	271.6	393.5	556.8	496.3	338.0	118.3		2654.4
Ratio of Supply to Demand		146.0%	493.4%	1863.8%	3066.9%	1430.7%	958.4%	514.3%	410.2%	136.7%	110.7%	136.9%	309.2%		306.9%
Supply – Demand (millions m3)		111.7	303.6	422.5	473.6	495.6	708.2	1125.3	1220.8	204.6	52.9	124.6	247.5		5491.4

Table 4-9 (continued)

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean (m3/sec)	Ann. Tot. (mill. m3)
Subbasins Contributing to Paktya, Paktyka Area															
sb116	avg monthly flow	9.75	14.72	17.23	17.27	16.14	23.94	57.11	31.18	8.31	6.14	6.86	5.31	17.83	562.3
sb117	avg monthly flow	12.08	18.25	21.35	21.40	19.99	29.66	70.77	38.64	10.30	7.61	8.51	6.58	22.09	696.7
total monthly flow (m3/sec)		21.82	32.97	38.57	38.68	36.13	53.60	127.87	69.82	18.61	13.75	15.37	11.89	39.92	1259.0
total monthly flow (millions m3)		58.4	85.5	103.3	103.6	87.4	143.6	331.4	187.0	48.2	36.8	41.2	30.8	39.87	1257.3
	monthly demand wheat	12.4	5.8	1.8	1.2	2.8	6.2	12.8	16.0	3.6	0.0	0.0	0.0		62.7
	monthly demand other	2.2	0.0	0.0	0.0	0.0	0.0	2.8	4.9	13.0	12.9	8.5	3.0		47.3
	monthly demand maize	9.3	0.0	0.0	0.0	0.0	0.0	12.1	21.1	56.1	55.7	36.9	13.0		204.1
	monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.7	3.5	3.5	1.1		13.2
total monthly demand (millions m3)		23.9	5.8	1.8	1.2	2.8	6.2	27.7	42.4	77.3	72.1	48.9	17.1		327.3
total gross demand (n=0.50)		47.7	11.6	3.6	2.4	5.6	12.4	55.4	84.9	154.6	144.3	97.7	34.3		654.6
	Ratio of Supply to Demand	122.4%	735.4%	2864.7%	4308.9%	1558.1%	1155.7%	598.3%	220.3%	31.2%	25.5%	42.1%	90.0%		192.1%
Supply – Demand (millions m3)		10.7	73.8	99.7	101.2	81.8	131.1	276.0	102.1	−106.4	−107.4	−56.6	−3.4		602.7
Subbasin Contributing to Ghazni Area															
sb201	avg monthly flow (m3/sec)	6.71	10.34	12.25	12.34	11.22	14.67	22.96	14.71	3.68	2.98	4.05	3.45	9.95	313.6
total monthly flow (millions m3)		18.0	26.8	32.8	33.0	27.1	39.3	59.5	39.4	9.5	8.0	10.9	8.9	9.93	313.2
	monthly demand wheat	17.6	8.3	2.6	1.7	4.0	8.8	18.2	22.8	5.1	0.0	0.0	0.0		89.1
	monthly demand other	3.2	0.0	0.0	0.0	0.0	0.0	4.1	7.2	19.2	19.1	12.6	4.5		69.9
	monthly demand maize	4.7	0.0	0.0	0.0	0.0	0.0	6.2	10.8	28.6	28.5	18.8	6.6		104.2
total monthly demand (millions m3)		25.6	8.3	2.6	1.7	4.0	8.8	28.5	40.7	52.9	47.5	31.4	11.1		263.1
total gross demand (n=0.50)		51.1	16.5	5.1	3.4	8.0	17.6	57.0	81.5	105.9	95.1	62.9	22.2		526.3
	Ratio of Supply to Demand	35.1%	162.4%	640.4%	967.9%	340.7%	222.7%	104.3%	48.4%	9.0%	8.4%	17.3%	40.3%		59.5%
Supply – Demand (millions m3)		−33.2	10.3	27.7	29.6	19.2	21.6	2.5	−42.0	−96.3	−87.1	−52.0	−13.3		−213.0
Subbasins Contributing to Badghis, Herat, Ghor Area															
sb301	avg monthly flow	0.00													
sb302	avg monthly flow	7.47	7.19	10.54	10.02	11.02	33.15	147.32	196.85	101.98	68.20	7.99	8.06	50.82	1602.5
sb303	avg monthly flow	3.83	5.25	5.38	5.60	7.76	14.41	26.30	20.96	4.90	1.65	1.58	2.75	8.36	263.7
sb304	avg monthly flow	2.84	3.90	3.99	4.16	5.76	10.70	19.53	15.56	3.64	1.23	1.17	2.04	6.21	195.9
sb305	avg monthly flow	11.28	15.46	15.85	16.49	22.87	42.46	77.52	61.75	14.43	4.87	4.65	8.10	24.64	777.2
sb306	avg monthly flow	3.19	4.37	4.48	4.66	6.46	12.00	21.91	17.45	4.06	1.38	1.31	2.29	6.97	219.7
total monthly flow (m3/sec)		28.61	36.16	40.24	40.93	53.88	112.72	292.58	312.58	129.02	77.32	16.70	23.24	97.00	3058.9
total monthly flow (millions m3)		76.6	93.7	107.8	109.6	130.3	301.9	758.4	837.2	334.4	207.1	44.7	60.2	97.10	3062.1
	monthly demand wheat	64.4	30.1	9.4	6.2	14.6	32.2	66.5	83.1	18.7	0.0	0.0	0.0		325.3
	monthly demand other	13.6	0.0	0.0	0.0	0.0	0.0	17.7	30.9	82.1	81.7	54.0	19.1		299.1
	monthly demand maize	4.1	0.0	0.0	0.0	0.0	0.0	5.3	9.3	24.6	24.5	16.2	5.7		89.7
	monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	32.8	24.3	24.4	7.8		92.7
total monthly demand (millions m3)		82.1	30.1	9.4	6.2	14.6	32.2	89.5	126.6	158.3	130.5	94.6	32.6		806.6
total gross demand (n=0.50)		164.3	60.3	18.7	12.5	29.1	64.4	179.1	253.3	316.6	261.1	189.3	65.1		1613.6
	Ratio of Supply to Demand	46.6%	155.5%	576.1%	876.9%	447.9%	468.5%	423.5%	330.6%	105.6%	79.3%	23.6%	92.5%		189.8%
Supply – Demand (millions m3)		−87.6	33.4	89.1	97.2	101.2	237.5	579.3	583.9	17.8	−54.0	−144.5	−4.9		1448.4

Table 4-9 (continued)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean (m3/sec)	Ann. Tot. (mill. m3)
Subbasins Contributing to Samangan, Balk, Jawzjan, Faryab Area														
sb401 avg monthly flow	18.38	25.19	25.82	26.87	37.26	69.19	126.30	100.62	23.51	7.93	7.58	13.19	40.15	1266.3
sb402 avg monthly flow	16.42	22.50	23.06	24.00	33.28	61.80	112.81	89.87	21.00	7.08	6.77	11.78	35.86	1131.0
sb403 avg monthly flow	26.73	36.62	37.54	39.07	54.17	100.58	183.62	146.28	34.17	11.53	11.02	19.18	58.37	1840.9
sb404 avg monthly flow	10.65	14.60	14.96	15.57	21.59	40.09	73.18	58.30	13.62	4.59	4.39	7.64	23.27	733.7
sb405 avg monthly flow	0.00													
total monthly flow (m3/sec)	72.18	98.91	101.39	105.52	146.29	271.65	495.91	395.08	92.29	31.13	29.75	51.80	157.66	4971.9
total monthly flow (millions m3)	193.3	256.4	271.6	282.6	353.9	727.6	1285.4	1058.2	239.2	83.4	79.7	134.3	157.46	4965.5
monthly demand wheat	200.0	93.6	29.0	19.4	45.2	100.0	206.5	258.1	58.1	0.0	0.0	0.0		1009.9
monthly demand other	24.0	0.0	0.0	0.0	0.0	0.0	31.3	54.5	145.0	144.2	95.4	33.7		528.1
monthly demand maize	11.1	0.0	0.0	0.0	0.0	0.0	14.5	25.2	67.1	66.7	44.1	15.6		244.4
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	52.4	38.9	39.0	12.4		148.1
total monthly demand (millions m3)	235.2	93.6	29.0	19.4	45.2	100.0	252.2	343.2	322.6	249.8	178.5	61.7		1930.4
total gross demand (n=0.50)	470.4	187.1	58.1	38.7	90.3	200.0	504.4	686.4	645.2	499.7	357.0	123.3		3860.8
Ratio of Supply to Demand	41.1%	137.0%	467.6%	730.0%	391.8%	363.7%	254.8%	154.2%	37.1%	16.7%	22.3%	108.8%		128.6%
Supply – Demand (millions m3)	–277.1	69.2	213.5	243.9	263.6	527.5	781.0	371.8	–406.0	–416.3	–277.3	10.9		1104.8
Subbasins Contributing to Badakshan, Bamian, Baghlan, Kunduz, Takhar Area														
sb406 avg monthly flow	0.00													
sb407 avg monthly flow	106.43	106.43	100.49	90.04	84.75	91.98	127.07	234.39	502.33	297.35	151.70	83.06	164.67	5193.0
sb408 avg monthly flow	56.25	56.25	53.12	47.59	44.80	48.62	67.16	123.89	265.51	157.16	80.18	43.91	87.04	2744.8
sb409 avg monthly flow	81.31	81.31	76.77	68.79	64.75	70.27	97.07	179.07	383.76	227.16	115.90	63.47	125.80	3967.3
total monthly flow (m3/sec)	243.98	243.98	230.38	206.42	194.30	210.86	291.30	537.35	1151.59	681.67	347.78	190.45	377.51	11905.0
total monthly flow (millions m3)	653.5	632.4	617.0	552.9	470.0	564.8	755.0	1439.2	2984.9	1825.8	931.5	493.7	378.01	11920.8
monthly demand wheat	110.2	51.5	16.0	10.7	24.9	55.1	113.7	142.2	32.0	0.0	0.0	0.0		556.3
monthly demand other	22.8	0.0	0.0	0.0	0.0	0.0	29.7	51.8	137.8	137.1	90.6	32.0		501.9
monthly demand maize	2.9	0.0	0.0	0.0	0.0	0.0	3.7	6.5	17.2	17.1	11.3	4.0		62.6
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8	280.3	207.9	208.8	66.6		792.3
total monthly demand (millions m3)	135.9	51.5	16.0	10.7	24.9	55.1	147.2	229.2	467.3	362.1	310.7	102.5		1913.1
total gross demand (n=0.50)	271.8	103.1	32.0	21.3	49.8	110.2	294.3	458.4	934.6	724.2	621.4	205.1		3826.1
Ratio of Supply to Demand	240.4%	613.5%	1928.8%	2592.4%	944.5%	512.5%	256.6%	314.0%	319.4%	252.1%	149.9%	240.7%		311.6%
Supply – Demand (millions m3)	381.7	529.3	585.1	531.6	420.3	454.6	460.7	980.8	2050.3	1101.5	310.1	288.6		8094.6
Subbasins Contributing to Kabul, Logar, Wardak, Parwan, Kapisa, Laghman, Konar, Nangarhar Area														
sb501 avg monthly flow	271.55	452.34	462.84	537.11	478.59	537.11	1277.50	798.16	170.28	96.02	79.52	159.78	443.40	13983.1
sb502 avg monthly flow	27.01	44.99	46.03	53.42	47.60	53.42	127.05	79.38	16.94	9.55	7.91	15.89	44.10	1390.7
sb503 avg monthly flow	55.34	92.19	94.33	109.46	97.54	109.46	260.36	162.67	34.70	19.57	16.21	32.56	90.37	2849.8
sb504 avg monthly flow	93.88	156.38	160.01	185.69	165.46	185.69	441.66	275.94	58.87	33.20	27.49	55.24	153.29	4834.2
total monthly flow (m3/sec)	447.79	745.90	763.21	885.68	789.19	885.68	2106.57	1316.14	280.79	158.33	131.12	263.48	731.16	23057.7
total monthly flow (millions m3)	1199.3	1933.4	2044.2	2372.2	1909.2	2372.2	5460.2	3525.2	727.8	424.1	351.2	682.9	729.39	23001.9
monthly demand wheat	82.1	38.4	11.9	7.9	18.5	41.1	84.8	106.0	23.8	0.0	0.0	0.0		414.6
monthly demand other	17.8	0.0	0.0	0.0	0.0	0.0	23.2	40.4	107.5	106.9	70.7	24.9		391.3
monthly demand maize	12.1	0.0	0.0	0.0	0.0	0.0	15.7	27.4	73.0	72.6	48.0	16.9		265.6
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	119.3	88.5	88.9	28.3		337.3
total monthly demand (millions m3)	112.0	38.4	11.9	7.9	18.5	41.1	123.6	186.0	323.6	267.9	207.5	70.2		1408.7
total gross demand (n=0.50)	224.1	76.8	23.8	15.9	37.1	82.1	247.3	372.0	647.1	535.9	415.0	140.4		2817.5
Ratio of Supply to Demand	535.3%	2516.7%	8574.1%	14924.7%	5147.9%	2888.7%	2208.0%	947.7%	112.5%	79.1%	84.6%	486.4%		816.4%
Supply – Demand (millions m3)	975.3	1856.5	2020.4	2356.3	1872.1	2290.1	5212.9	3153.2	80.7	–111.8	–63.8	542.5		20184.4

TOTAL ANNUAL SUPPLY (millions m3)	58522.3
TOTAL ANNUAL DEMAND (millions m3)	16929.4

DIFFERENCE (millions m3)	41592.9

Source: Analysis of Pre–War Regional Supply and Demand by Nathan–Berger team.

resources available for the study did not permit realistic estimation of probabilities for any such variations.

Water Shortage Locations

In this section, the term "water shortage" describes a situation where water supply conditions for optimum plant growth have not been met. The greater the shortage, the greater the impact on crop yields. It should be noted, however, that the impact of less than optimum water supply varies considerably depending on the type of crop grown. For example, maize is particularly sensitive to water availability throughout its growing season and shortages during critical periods (such as flowering) can cause crop failure. Wheat, by contrast, is quite resilient and will often produce a crop with only one or two irrigations (although the yield may be lower).

Comparison of Supply Versus Demand, Prewar Conditions

For the southwestern (Nimroz), western (Farah), northwestern (Badghis, Herat, Ghor), central (Ghazni), northern (Samangan, Balk, Jowzjan, Faryab) and southeastern (Paktyka, Paktya) regions, water supply shortages occur in the late spring, summer, and early fall months (see Table 4-9, ratio of supply to demand). In each of these regions, the high water requirements of maize and rice during the summer coupled with the lower streamflows during this period are the cause of the shortages. The fall deficit is the result of low streamflows and relatively high water requirements for fall planting of wheat.

The southern (Helmand, Qandahar, Oruzgan, and Zabul), and northeastern (Badakshan, Bamian, Baghlan, Konduz, and Takhar) regions experience no water supply shortages. Water supplies are adequate for the 1978-1979 (prewar) crop demands of these regions.

The eastern (Kabul, Lowgar, Wardak, Parwan, Laghman, Konar, and Nangarhar) region experiences slight water shortages in the summer. These shortages are the result of the high demands of rice and maize and the lower river flows during this period.

The northwestern region (Badghis, Herat, and Ghor) experiences shortages in the late summer and fall. Low flows in this season coupled with late season demand for maize and rice and fall planting requirements for wheat are the cause of these shortages.

The central region (Ghazni) experiences the greatest overall shortage, with annual supply less than 100 percent of annual demand (see Table 4-9). This result is perhaps an artifact of the limitations of the method of analysis

used. As mentioned previously, it was expected that water supply would be underestimated for this region because of the method of defining regional areas. Like the western and southwestern regions, which are composed of only one province each (Farah and Nimroz respectively), the central region includes only Ghazni. Agricultural demand for Ghazni province, a relatively productive province, is counted as demand for the region. However, the central region counts as its water supply only one watershed, the only one contained within the regional boundaries (see Table 4-3 and Figure 2-7). Both Farah and Nimroz count additional watersheds for their sources of supply. As explained previously, Ghazni is a high plateau with most water draining from it and not to it. All other watersheds straddle the provincial boundary and are counted as water supply elsewhere.

The problem with the central region illustrates the limitations of the "provincialization" of watershed boundaries. Ideally, the watershed boundaries themselves should provide the basis for determining both water supply and agricultural demand for water. In order for this approach to be successful, agricultural data would have to be available on this same basis.

While the adjustments to provincial boundaries to some extent violate topographic imperatives, these modifications permit comparisons of weather data and surface water flows with data on agricultural production. The GIS system being developed by DAI and Earthsat has the potential to present information on rainfall, snow accumulation, and agricultural production by drainage regions whose boundaries are determined solely on the basis of topography (i.e., without the adjustments to provincial boundaries used in this report). However, the satellite information available on agriculture from DAI/Earthsat for the present study was limited to a relatively small group of regions of Afghanistan located near the Pakistan border. "Provincialized" drainage basin boundaries have therefore been created in order to make rough comparisons of the available data on nationwide. When GIS coverage is extended to the entire country, a more refined analysis may be possible.

Current Conditions Model

The current conditions model attempts to account for the changes that have taken place in agricultural land use since the war began. Significant reductions in cultivated areas have occurred in many regions, and this is reflected in the model by the amount of land area allocated to the different crop types. As discussed below, this allocation is based on SCA and Nathan-Berger data for cereal crops. Water supply conditions are assumed to be the same; average precipitation and streamflows are assumed to be unchanged.

SCA data on crop yields, crop production data from the Nathan-Berger AFGRAIN model, and other sources were used to derive a first estimate of crop areas for current conditions. Crop area data were then

adjusted to match available countrywide crop statistics. Table 4-10 contains the results of this analysis.

The current conditions model assumes that the amount of area irrigated by groundwater in each province has diminished only modestly since 1978-1979. A somewhat arbitrary 10 percent reduction has been applied to the prewar groundwater figures to reflect the significant resources (work of VITA and others) that have been devoted to rehabilitation of *karezes* and wells.

Crop monthly demands (see Table 4-8) and system losses (50 percent) are assumed to be the same in the current conditions model.

Results of this analysis for each of the regions are summarized in Table 4-11 and described next.

Comparison of Prewar and Current Water Supply and Demand Conditions

The agricultural situation in Afghanistan has changed significantly in the decade since the war began. It has been estimated that irrigated area has declined by 21 percent between the years 1978-1979 and 1987-1988 with the largest declines reported in the region that includes Helmand, Kandahar, Nimroz, Uruzgan, Zabul, Ghazni, and Paktyka provinces.[32] Because irrigated lands make up such a large portion of the total cultivated land in these provinces (about 80 percent overall), the area has been particularly hard-hit by damage and destruction of both the modern and traditional irrigation systems. Significant numbers of people have been forced to flee.

Based on the average water supply conditions and estimates of irrigated crop areas in the extensively developed southern agricultural region composed of Helmand, Kandahar, Zabul, and Uruzgan, the 1978-1979 water supply model indicated surplus water available in the region. No water shortages were experienced in any month. Currently, and primarily as a result of damage to the Helmand-Arghandab water distribution network, the amount of land irrigated has been significantly reduced (about 107,000 ha. less). However, the water supply is unchanged. On the basis of reports by Assifi and others,[33] rehabilitation of the existing distribution network appears to require relatively minor repairs. Because surplus water is available for irrigation, the southern region appears to offer one of the greater potentials for bringing large regions of previously irrigated land back into production.

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[32]Nathan-Berger, *Afghanistan Land Ownership Study*, 1991.

[33]Assifi, A. *An Assessment of Helmand Valley Water Control System*, Draft Report, Office of the A.I.D. Representative for Afghanistan, 1991.

Table 4-10. Approximate Irrigated Crop Areas, 1989-1990 (ha.)

Region and Province	Wheat	Rice	Maize	Barley	Estimate of Total Irrigated Grain	Other Crops	Estimate of Total Irrigated Area
West:							
Farah	28,467	3,045	55,346	1,329	88,187	12,558	100,745
Southwest:							
Nimroz	9,941	0	20,546	0	30,487	5,474	35,961
Southern:							
Helmand	58,163	0	56,162	0	114,325	28,866	143,191
Qandahar	50,549	0	37,396	0	87,945	26,162	114,107
Oruzgan	50,411	10,242	52,622	3,353	116,628	8,533	125,161
Zabul	34,134	0	4,000	0	38,134	5,877	44,011
total	193,257	10,242	150,180	3,353	357,032	69,438	426,470
Southeastern:							
Paktya	16,343	1,920	12,972	0	31,235	5,474	36,709
Paktika	9,268	0	34,085	0	43,353	3,623	46,976
	25,611	1,920	47,057	0	74,588	9,097	83,685
Central:							
Ghazni	34,289	0	30,065	688	65,042	13,282	78,324
Eastern:							
Kabul	43,048	0	1,000	0	44,048	15,880	59,928
Logar	9,664	2,000	6,738	0	18,402	6,118	24,520
Wardak	15,854	4,400	1,760	1,286	23,300	4,428	27,728
Parwan	21,273	0	1,000	0	22,273	13,685	35,958
Kapisa	39,940	4,140	2,360	1,527	47,967	4,830	52,797
Laghman	11,600	14,000	11,101	0	36,701	6,052	42,753
Konar	8,190	5,148	20,613	1,141	35,092	4,830	39,922
Nangarhar	22,616	4,136	16,600	0	43,352	14,571	57,923
total	172,185	33,824	61,172	3,954	271,135	70,394	341,529
Northeastern:							
Badakshan	24,767	1,800	20,829	5,389	52,785	9,338	62,123
Bamian	16,388	1,100	0	1,913	19,401	6,279	25,680
Baghlan	27,766	41,600	0	0	69,366	19,723	89,089
Kunduz	79,657	37,373	0	1,172	118,202	36,881	155,083
Takhar	35,664	15,000	5,504	1,913	58,081	8,855	66,936
total	184,242	96,873	26,333	10,387	317,835	81,076	398,911

Table 4-10 (cont'd)

Region and Province	Wheat	Rice	Maize	Barley	Estimate of Total Irrigated Grain	Other Crops	Estimate of Total Irrigated Area
Northern:							
Samangan	33,972	0	3,726	1,726	39,424	7,808	47,232
Balkh	98,225	19,008	9,840	7,871	134,944	39,526	174,470
Jawzjan	83,213	0	9,109	21,627	113,949	19,723	133,672
Faryab	66,200	0	12,495	10,741	89,436	16,100	105,536
total	281,610	19,008	35,170	41,965	377,753	83,157	460,910
Northwestern:							
Badghis	13,600	2,560	11,663	1,313	29,136	6,601	35,737
Herat	69,307	7,528	6,700	9,086	92,621	39,043	131,664
Ghor	17,490	0	13,768	925	32,183	2,880	35,063
total	100,397	10,088	32,131	11,324	153,940	48,524	202,464
TOTAL	1,030,000	175,000	458,000	73,000	1,736,000	393,000	2,129,000

Sources: The Agricultural Survey of Afghanistan, Third Report Crops and Yields, the Swedish Committee of Afghanistan, 1989;
AFGRAIN Afghanistan Regional Foodgrain Situation, Nathan–Berger, 1990. Macroeconomic Data Development: Phase II, Vol. 2, Table A11–A10, Nathan–Berger, 1991.

Table 4-11. Regional Supply and Demand, Current Conditions

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean Ann. (m3/sec)	Total Ann. (millions m3
Subbasins Contributing to Farah Area														
sb101 avg monthly flow	0.00													
sb102 avg monthly flow	0.00													
sb103 avg monthly flow	10.24	12.90	19.08	32.10	57.01	177.46	93.13	173.83	23.81	9.40	5.09	8.12	51.85	1635.0
sb104 avg monthly flow	1.15	6.56	13.19	24.52	105.74	218.93	244.56	92.57	34.18	6.96	1.99	1.31	62.64	1975.4
total monthly flow (m3/sec)	11.39	19.46	32.27	56.63	162.75	396.39	337.68	266.40	57.99	16.36	7.09	9.43	114.49	3610.5
total monthly flow (millions m3)	30.5	50.5	86.4	151.7	393.7	1061.7	875.3	713.5	150.3	43.8	19.0	24.4	114.18	3600.8
monthly demand wheat	5.3	2.5	0.8	0.5	1.2	2.6	5.5	6.8	1.5	0.0	0.0	0.0		26.7
monthly demand other	1.1	0.0	0.0	0.0	0.0	0.0	1.4	2.4	6.5	6.5	4.3	1.5		23.7
monthly demand maize	4.7	0.0	0.0	0.0	0.0	0.0	6.2	10.8	28.7	28.5	18.8	6.6		104.3
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.0	2.2	2.2	0.7		8.4
total monthly demand (millions m3)	11.1	2.5	0.8	0.5	1.2	2.6	13.0	20.3	39.7	37.2	25.3	8.9		163.1
total gross demand (n=0.50)	22.2	4.9	1.5	1.0	2.4	5.3	26.1	40.7	79.3	74.3	50.6	17.7		326.1
Ratio of Supply to Demand	137.3%	1020.7%	5635.1%	14831.1%	16499.9%	20093.9%	3359.1%	1755.0%	189.5%	59.0%	37.5%	137.9%		1104.2%
Supply – Demand (millions m3)	8.3	45.5	84.9	150.6	391.3	1056.4	849.2	672.9	71.0	−30.5	−31.7	6.7		3274.7
Subbasins Contributing to Nimroz Area														
sb105 avg monthly flow	0.54	3.08	6.16	11.50	49.57	102.62	114.64	43.39	16.02	3.26	0.94	0.61	29.36	926.0
sb106 avg monthly flow	0.78	4.47	8.98	16.70	72.01	149.10	166.55	63.04	23.28	4.74	1.36	0.89	42.66	1345.3
total monthly flow (m3/sec)	1.32	7.55	15.17	28.20	121.58	251.72	281.19	106.44	39.30	8.01	2.29	1.50	72.02	2271.3
total monthly flow (millions m3)	3.5	19.6	40.6	75.5	294.1	674.2	728.8	285.1	101.9	21.4	6.1	3.9	71.50	2254.9
monthly demand wheat	3.1	1.5	0.5	0.3	0.7	1.6	3.2	4.1	0.9	0.0	0.0	0.0		15.9
monthly demand other	0.8	0.0	0.0	0.0	0.0	0.0	1.1	1.9	5.0	5.0	3.3	1.2		18.4
monthly demand maize	3.1	0.0	0.0	0.0	0.0	0.0	4.1	7.1	19.0	18.8	12.5	4.4		69.0
total monthly demand (millions m3)	7.1	1.5	0.5	0.3	0.7	1.6	8.4	13.1	24.9	23.9	15.8	5.6		103.2
total gross demand (n=0.50)	14.2	2.9	0.9	0.6	1.4	3.1	16.8	26.1	49.8	47.7	31.6	11.1		206.5
Ratio of Supply to Demand	24.9%	665.9%	4455.5%	12422.7%	20734.8%	21465.5%	4331.3%	1090.6%	204.4%	44.9%	19.5%	35.0%		1092.0%
Supply – Demand (millions m3)	−10.7	16.6	39.7	74.9	292.7	671.1	712.0	258.9	52.0	−26.3	−25.4	−7.2		2048.4
Subbasins Contributing to Helmand, Qandahar, Oruzgan, Zabul Area														
sb107 avg monthly flow	24.00	26.85	26.79	27.38	37.45	95.04	194.31	170.53	75.15	34.61	22.04	20.66	62.90	1983.6
sb108 avg monthly flow	0.76	2.21	5.57	5.89	19.30	58.61	54.85	18.98	4.20	2.21	0.66	0.62	14.49	456.9
sb109 avg monthly flow	85.51	88.11	95.41	104.47	88.12	11.21	97.55	290.83	164.48	125.73	126.77	100.75	114.91	3623.9
sb110 avg monthly flow	9.55	10.69	10.66	10.90	14.91	37.83	77.34	67.87	29.91	13.77	8.77	8.22	25.03	789.5
sb111 avg monthly flow	8.89	13.46	17.76	20.82	29.15	48.76	68.49	35.78	14.04	11.97	8.80	7.68	23.80	750.7
sb112 avg monthly flow	3.70	5.61	7.41	8.67	12.15	20.33	28.54	14.91	5.85	4.99	3.67	3.20	9.92	312.8
sb113 avg monthly flow	0.00	0.00	1.72	2.66	10.83	13.16	10.04	2.15	0.06	6.61	1.10	0.00	4.03	127.0
sb114 avg monthly flow	0.00	0.00	0.43	0.67	2.72	3.31	2.53	0.54	0.01	1.66	0.28	0.00	1.01	31.9
sb115 avg monthly flow	0.00	0.00	0.91	1.41	5.73	8.97	5.32	1.14	0.03	3.50	0.58	0.00	2.13	67.2
total monthly flow (m3/sec)	132.42	146.92	166.68	182.85	220.35	295.23	538.96	602.73	293.74	205.06	172.69	141.13	258.23	8143.5
total monthly flow (millions m3)	354.7	380.8	446.4	489.7	533.1	790.7	1397.0	1614.4	761.4	549.2	462.5	365.8	258.30	8145.8
monthly demand wheat	47.8	22.4	6.9	4.6	10.8	23.9	49.4	61.7	13.9	0.0	0.0	0.0		241.5
monthly demand other	9.2	0.0	0.0	0.0	0.0	0.0	12.0	20.9	55.6	55.3	36.5	12.9		202.4
monthly demand maize	18.3	0.0	0.0	0.0	0.0	0.0	23.8	41.4	110.3	109.7	72.5	25.6		401.6
monthly demand rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	9.7	7.2	7.2	2.3		27.4
total monthly demand (millions m3)	75.3	22.4	6.9	4.6	10.8	23.9	85.1	125.0	189.4	172.1	116.3	40.8		872.8
total gross demand (n=0.50)	150.7	44.7	13.9	9.3	21.6	47.8	170.2	250.1	378.9	344.3	232.5	81.6		1745.6
Ratio of Supply to Demand	235.4%	851.0%	3214.6%	5289.7%	2467.6%	1653.0%	820.6%	645.6%	200.9%	159.5%	198.9%	448.4%		466.6%
Supply – Demand (millions m3)	204.0	336.1	432.5	480.5	511.5	742.9	1226.7	1364.3	382.5	204.9	230.0	284.2		6400.2

Table 4-11 (cont'd)

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean Ann. (m3/sec)	Total Ann. (millions m3
Subbasins Contributing to Paktya, Paktyka Area															
sb116	avg monthly flow	9.75	14.72	17.23	17.27	16.14	23.94	57.11	31.18	8.31	6.14	6.86	5.31	17.83	562.3
sb117	avg monthly flow	12.08	18.25	21.35	21.40	19.99	29.66	70.77	38.64	10.30	7.61	8.51	6.58	22.09	696.7
total monthly flow (m3/sec)		21.82	32.97	38.57	38.68	36.13	53.60	127.87	69.82	18.61	13.75	15.37	11.89	39.92	1259.0
total monthly flow (millions m3)		58.4	85.5	103.3	103.6	87.4	143.6	331.4	187.0	48.2	36.8	41.2	30.8	39.87	1257.3
monthly demand wheat		7.0	3.3	1.0	0.7	1.6	3.5	7.2	9.0	2.0	0.0	0.0	0.0		35.4
monthly demand other		1.2	0.0	0.0	0.0	0.0	0.0	1.5	2.7	7.1	7.1	4.7	1.7		26.0
monthly demand maize		5.3	0.0	0.0	0.0	0.0	0.0	6.9	12.0	31.8	31.6	20.9	7.4		115.9
monthly demand rice		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.3	2.5	2.5	0.8		9.4
total monthly demand (millions m3)		13.5	3.3	1.0	0.7	1.6	3.5	15.6	24.0	44.3	41.2	28.1	9.8		186.6
total gross demand (n=0.50)		26.9	6.6	2.0	1.4	3.2	7.0	31.3	48.0	88.7	82.5	56.2	19.7		373.3
Ratio of Supply to Demand		217.1%	1304.6%	5081.9%	7643.8%	2763.9%	2050.1%	1060.6%	389.3%	54.4%	44.7%	73.3%	156.7%		336.8%
Supply – Demand (millions m3)		31.5	78.9	101.3	102.2	84.2	136.6	300.2	139.0	−40.4	−45.6	−15.0	11.2		884.0
Subbasin Contributing to Ghazni Area															
sb201	avg monthly flow (m3/sec)	6.71	10.34	12.25	12.34	11.22	14.67	22.96	14.71	3.68	2.98	4.05	3.45	9.95	313.6
total monthly flow (millions m3)		18.0	26.8	32.8	33.0	27.1	39.3	59.5	39.4	9.5	8.0	10.9	8.9	9.93	313.2
monthly demand wheat		11.6	5.4	1.7	1.1	2.6	5.8	11.9	14.9	3.4	0.0	0.0	0.0		58.3
monthly demand other		2.1	0.0	0.0	0.0	0.0	0.0	2.8	4.8	12.8	12.7	8.4	3.0		46.6
monthly demand maize		4.8	0.0	0.0	0.0	0.0	0.0	6.2	10.9	29.0	28.8	19.1	6.7		105.6
total monthly demand (millions m3)		18.5	5.4	1.7	1.1	2.6	5.8	20.9	30.6	45.2	41.6	27.5	9.7		210.6
total gross demand (n=0.50)		37.0	10.8	3.4	2.2	5.2	11.6	41.9	61.2	90.3	83.2	55.0	19.4		421.1
Ratio of Supply to Demand		48.6%	247.6%	977.6%	1477.6%	520.2%	340.0%	142.1%	64.4%	10.6%	9.6%	19.7%	46.0%		74.4%
Supply – Demand (millions m3)		−19.0	16.0	29.4	30.8	21.9	27.7	17.6	−21.8	−80.8	−75.2	−44.1	−10.5		−107.9
Subbasins Contributing to Badghis, Herat, Ghor Area															
sb301	avg monthly flow	0.00													
sb302	avg monthly flow	7.47	7.19	10.54	10.02	11.02	33.15	147.32	196.85	101.98	68.20	7.99	8.06	50.82	1602.5
sb303	avg monthly flow	3.83	5.25	5.38	5.60	7.76	14.41	26.30	20.96	4.90	1.65	1.58	2.75	8.36	263.7
sb304	avg monthly flow	2.84	3.90	3.99	4.16	5.76	10.70	19.53	15.56	3.64	1.23	1.17	2.04	6.21	195.9
sb305	avg monthly flow	11.28	15.46	15.85	16.49	22.87	42.46	77.52	61.75	14.43	4.87	4.65	8.10	24.64	777.2
sb306	avg monthly flow	3.19	4.37	4.48	4.66	6.46	12.00	21.91	17.45	4.08	1.38	1.31	2.29	6.97	219.7
total monthly flow (m3/sec)		28.61	36.16	40.24	40.93	53.88	112.72	292.58	312.58	129.02	77.32	16.70	23.24	97.00	3058.9
total monthly flow (millions m3)		76.6	93.7	107.8	109.6	130.3	301.9	758.4	837.2	334.4	207.1	44.7	60.2	97.10	3062.1
monthly demand wheat		40.6	19.0	5.9	3.9	9.2	20.3	41.9	52.4	11.8	0.0	0.0	0.0		205.2
monthly demand other		9.3	0.0	0.0	0.0	0.0	0.0	12.1	21.1	56.1	55.8	36.9	13.0		204.2
monthly demand maize		3.8	0.0	0.0	0.0	0.0	0.0	4.9	8.6	22.8	22.7	15.0	5.3		83.0
monthly demand rice		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	21.9	16.2	16.3	5.2		61.8
total monthly demand (millions m3)		53.7	19.0	5.9	3.9	9.2	20.3	58.9	84.3	112.5	94.7	68.1	23.5		554.1
total gross demand (n=0.50)		107.4	38.0	11.8	7.9	18.4	40.6	117.9	168.6	225.1	189.3	136.3	47.0		1108.3
Ratio of Supply to Demand		71.3%	246.5%	913.5%	1393.8%	710.2%	742.9%	643.3%	496.5%	148.6%	109.4%	32.8%	128.2%		276.3%
Supply – Demand (millions m3)		−30.8	55.7	96.0	101.8	112.0	261.3	640.5	668.6	109.3	17.8	−91.5	13.2		1953.8

Chapter 2

AFGHANISTAN'S WATER RESOURCES

This chapter presents information available on water resources in Afghanistan. Principal patterns of water flows and distribution in Afghanistan are described, and information available on climate, precipitation, glaciers and snow fields, watersheds, and water use are discussed. Comprehensive estimates of total sources and uses of water, believed to be the first of their kind to include all of Afghanistan, are presented.

Principal Patterns

Afghanistan's topographic profile resembles a peaked and rumpled hat with a very irregular brim. Four main river systems flow down from Afghanistan's mountainous center, across its lowlands, and into deserts or adjoining countries. Regions above 14,000 feet (which receive heavy snow) and those above 4,000 feet (which receive a combination of snow and rain) supply most sections of the country with water during the spring and early summer months. Most agriculture is carried out close to rivers and streams.

Much of Afghanistan's land area is mountainous. The Hindu Kush, Afghanistan's major mountain system, bisects the country from northeast to southwest, reaching elevations between 6,000 m and 7,000 m. The northeastern and central portions of the country form a high plateau with average elevations of about 2,000 m. General elevation declines rapidly in the southwest toward the Sistan Depression, where average elevations range around 500 m. Figure 2-1 shows elevations in Afghanistan.

Except in the extreme west and in portions of the southeast, the high mountains are, for the most part, uninhabited and treeless. However, because most precipitation in the country occurs during the winter and spring months, water provided by the mountains for most perennial streams is in the form of snowmelt. The major problem caused by this water supply has always been the heavy and often destructive flows that occur in the

mirab	Locally selected water master who supervises the operation of irrigation systems.
Permafrost	Permanent frozen layer at variable depth beneath the earth's surface.
SCA	Swedish Committee for Afghanistan
Stage	Height of a river above an arbitrary zero point.
Stream Gauge	Device used to measure river level or stage. Relationships between river stage and flow data are calculated at each gauge location.
Watershed	Topographically defined region contributing runoff to a river or stream. See Drainage Basin.
UNHCR	United Nations High Commission for Refugees
UNO	University of Nebraska at Omaha
USGS	United States Geological Survey

PREFACE

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Principal contributors to the work were Mr. Forrest Cookson, Mr. David Thirkill, Mr. Abdul Aziz Ferogh, Mr. Massaye Girma, and Mr. G. Whitney Azoy. The work was carried out under the supervision of Robert R. Nathan and Harvey A. Lerner. All research activities were conducted in the United States. No visits to Pakistan or field surveys in Afghanistan were carried out.

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Afghanistan Water Constraints Overview Analysis

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GLOSSARY

AFGRAIN	A model of Afghanistan's food grain situation presented in a Nathan-Berger report to O/AID/Rep under Delivery Order 10 (July 1990)
Barrage	Artificial obstruction in a watercourse designed to facilitate irrigation.
Cirque	Deep, steep-walled basin on a mountain, shaped like half a bowl.
CPSP	Mission Country Program Strategic Plan
Continental Climate	Climate characterized by sharp variation of seasonal and day-night temperatures: hot during summer, cold during winter, and generally dry.
Divide	Dividing ridge between drainage regions.
Drainage Basin	Topographically defined region contributing runoff to a river or stream. The boundary of the basin is called a divide.
Drainage Region	One of nine regions defined in this report as contributing runoff to one or more rivers and streams in Afghanistan. These regions are defined to correspond physical drainage boundaries as closely as possible to provincial boundaries.
Earthsat	Earth Satellite Corporation
EHD	Environmental Health Department of the Ministry of Health of the Government of Afghanistan
Escarpment	Long cliff or steep slope separating two comparatively level or gently sloping surfaces, resulting from erosion or faulting.
FAO	United Nations Food and Agriculture Organization
GIS	Geographic Information Service
HAVA	Helmand Arghandab Valley Authority
Lateral	Branch from a main canal that carries and distributes water within an irrigated region.